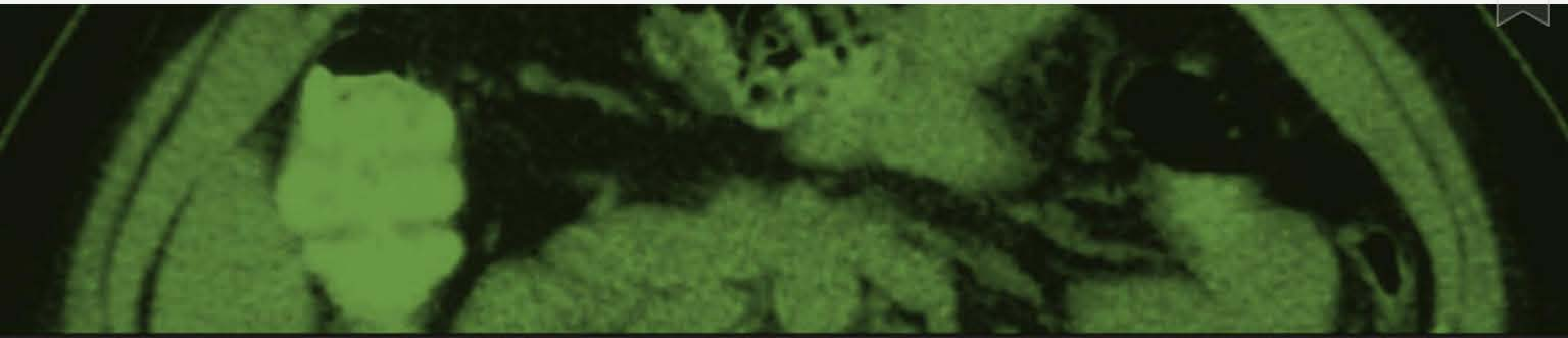

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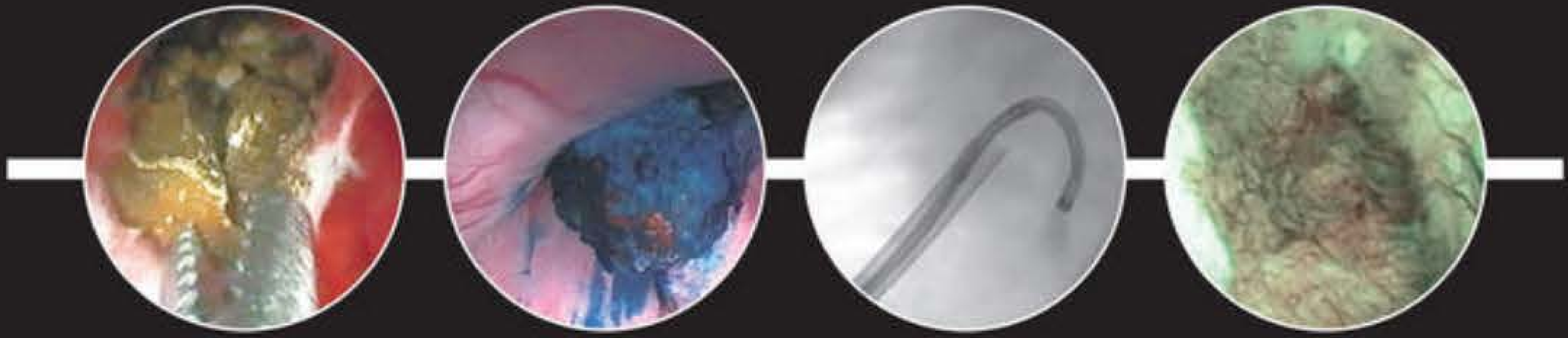

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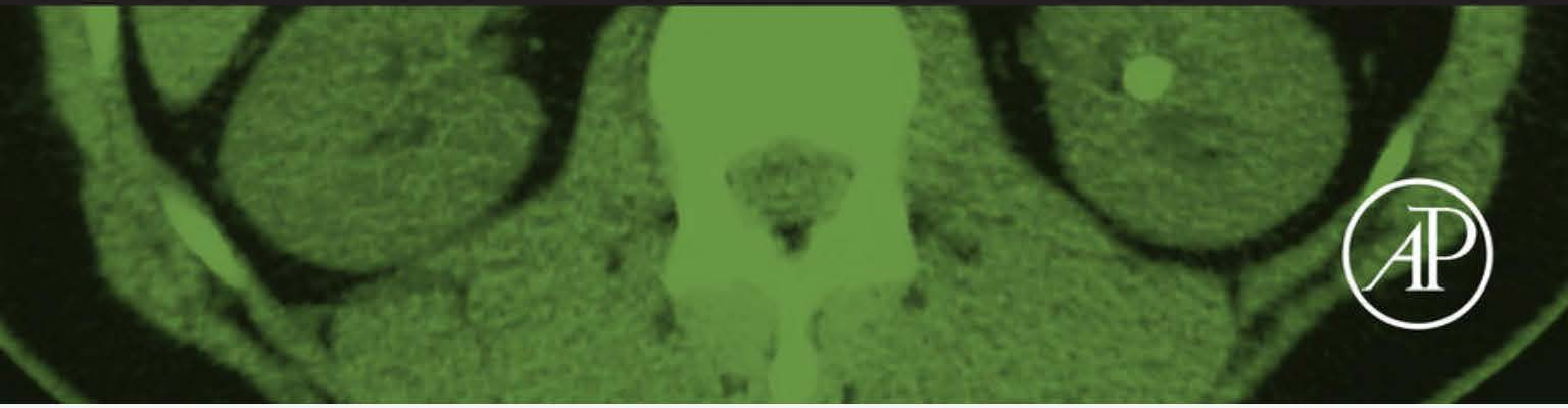

PERCUTANEOUS SURGERY OF THE UPPER URINARY TRACT

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HANDBOOK OF ENDOUROLOGY

Edited by

Petrişor A. Geavlete

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CHAPTER

1

History

Dragoş Georgescu, Răzvan Mulţescu, Bogdan Geavlete

The first historical report regarding the percutaneous approach of the kidney was by Thomas Hillier, in London. He approached and drained percutaneously the hydronephrotic kidney of a 4-year-old boy. Over a period of 5 years, until the patient died, multiple nephrostomies were placed in the attempt to create a permanent fistulous tract (Bloom et al., 1989).

After this first attempt, the percutaneous approach went into obscurity for more than 85 years until the mid-1950s, when Goodwin et al. (1955) reported a new series of percutaneous nephrostomies in 16 patients. Surprisingly, the method was abandoned again until the 1970s, when it was resumed. After that it became extremely popular, becoming the first option of treatment in the detriment of open nephrostomy. Moreover, the first intrarenal therapeutic maneuvers were attempted through the percutaneous tract.

Nephroscopy and the percutaneous extraction of some lithiasic fragments was first reported by Rupel and Brown (1941). They inserted a rigid cystoscope through a nephrostomy tract created during open nephrolithotomy to extract residual lithiasic fragments. However, this is a solitary case, and although the maneuver was a promising one, it was also forgotten for 35 years. Fernstrom and Johansson (1976) first described the extraction of kidney stones through a percutaneous tract created for this purpose by minimally invasive methods. Subsequently, the method was widely popularized in the 1980s by Wickham and Kellet in Great Britain and by Alken in Germany. It gradually gained ground, the indications diversified, and in 2005 the American Urology Association included in its guidelines the recommendation to use percutaneous nephrolithotomy as the first line of treatment for staghorn calculi (Preminger et al., 2005).

The percutaneous approach of the kidney was first achieved with rigid cystoscopes inserted through the nephrostomy tract. The growing popularity of this method determined the development of dedicated rigid nephroscopes, better adapted to the requirements of percutaneous renal approach. However, they had the disadvantage of not being able to explore the entire pyelocaliceal system by using a single access tract. The development of flexible endoscopes removed this inconvenience, allowing, at least theoretically, approach of the upper urinary tract at any level with minimal invasiveness.

Between 1974 and 1978, flexible endoscopes designed for the approach of the respiratory system or of the biliary tract were used successfully to extract some lithiasic fragments from the pyelocaliceal system during open surgical interventions or using the percutaneous nephrostomy tracts (Harris et al., 1975; Miki et al., 1978; Wilbur, 1981).

The utility of these instruments, the improvement of percutaneous interventions (which became routine interventions), as well as technological progress led to the development of flexible nephroscopes dedicated exclusively to urological use (Tsuchida, 1975, 1977; Pollack and Banner, 1982). Repeating the history of the evolution of rigid cystoscopes–rigid nephroscopes, the training ground for improving the use of these flexible instruments was represented by the bladder, an organ that is easier to approach endoscopically (Babayan and Wang, 2007). Today, these instruments can be used in the diagnosis and treatment of conditions of both organs, generically called cystonephroscopes.

In 1987 Valdivia Uria described the first percutaneous intervention in a patient in the supine position, and a decade later he reported more than 500 cases solved this way. Although the author considers this new technique to have a number of surgical and anesthetic advantages, subsequently confirmed by many other urologists, the technique did not manage to replace the interventions with the patient in the prone position, and is currently a complementary method (Valdivia Uria et al., 1990, 1998).

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Other indications developed as a consequence of the increasing use of the percutaneous approach for lithiasis: endopyelotomy, the approach of upper urinary tract urothelial tumors, of pyelocaliceal diverticula, renal abscesses, or extraction of foreign bodies.

The antegrade incision of ureteropelvic junction stenosis was first introduced almost 30 years ago by Wickham and Kellet. They called the intervention percutaneous pyelolysis, and practically they extrapolated the principles of intubated ureterotomy described by Albarran in 1903 and popularized by Davis in 1943 (Wickham and Kellet, 1983). In 1986 Smith renamed this procedure percutaneous endopyelotomy, a name that became classic (Badlani et al., 1986).

Regarding pyelocaliceal urothelial tumors, the first report of percutaneous approach was by Streem and Pontes (1986), the method being later popularized by Smith et al. (1987).

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CHAPTER

2

Equipment and Instruments in Percutaneous Nephrolithotomy

Răzvan Mulţescu, Dragoş Georgescu, Petrişor A. Geavlete, Bogdan Geavlete

2.1 OPERATING ROOM FACILITIES

2.1.1 Operating Table

The operating table used for percutaneous nephrolithotomy has to be mobile and modular, with a hydraulic system and adequate dimensions (Sabnis and Mishra, 2012). It has to ensure the dorsal, lateral, or ventral decubitus position of the patient, as well as the lithotomy position, and must allow cranio-caudal and lateral movement. The operating table's surface must be divided into segments that can be independently maneuvered so that the patient's position can be adapted to the intervention's particularities. A system for lifting the lumbar area is also very important (Sabnis and Mishra, 2012). The operating table should be radiotransparent to allow intraoperative fluoroscopic control. An adequate system for draining the irrigation fluid from the working field is also necessary.

2.1.2 Video Equipment

The introduction of video devices represented an important step in the development and improvement of the percutaneous approach, allowing increased comfort during surgery and enhanced visualization.

Recent progress in endoscopic video technology has considerably improved the accuracy of the image and of the intraoperative recordings during percutaneous interventions. The emergence and development of CCD (charge-coupled device) or CMOS (complementary metal–oxide–semiconductor) cameras, materialized by introducing "chip-on-the-stick" technologies in the digital endoscopes, has revolutionized endoscopic imaging. At this level, the optical image is converted into a digital signal which is transmitted to the monitor, ensuring a high-quality image and overcoming the shortcomings of the classic fiber optic systems (Lipkin et al., 2012).

Another element that has significantly improved the image quality is represented by the new halogen or xenon light sources. Numerous sources have an automatic mechanism for adjusting the light's intensity.

The possibility of intraoperative recording is very important for the educational process, but also for monitoring the patient's evolution and for forensic aspects (Lipkin et al., 2012).

2.1.3 Fluoroscopy Unit

Fluoroscopic monitoring is essential for performing percutaneous nephrolithotomy, and is the main interventional imaging method used in urology. It allows real-time images to be obtained, being necessary in all stages of the procedure (Lipkin et al., 2012). Renal puncture under fluoroscopic guidance is the most frequently used method for obtaining access to the urinary tract (Fig. 2.1).

During the lithotripsy procedures, it provides additional elements to direct visual control regarding the location of the stones and of the eventual migrated fragments, representing an essential element for performing the

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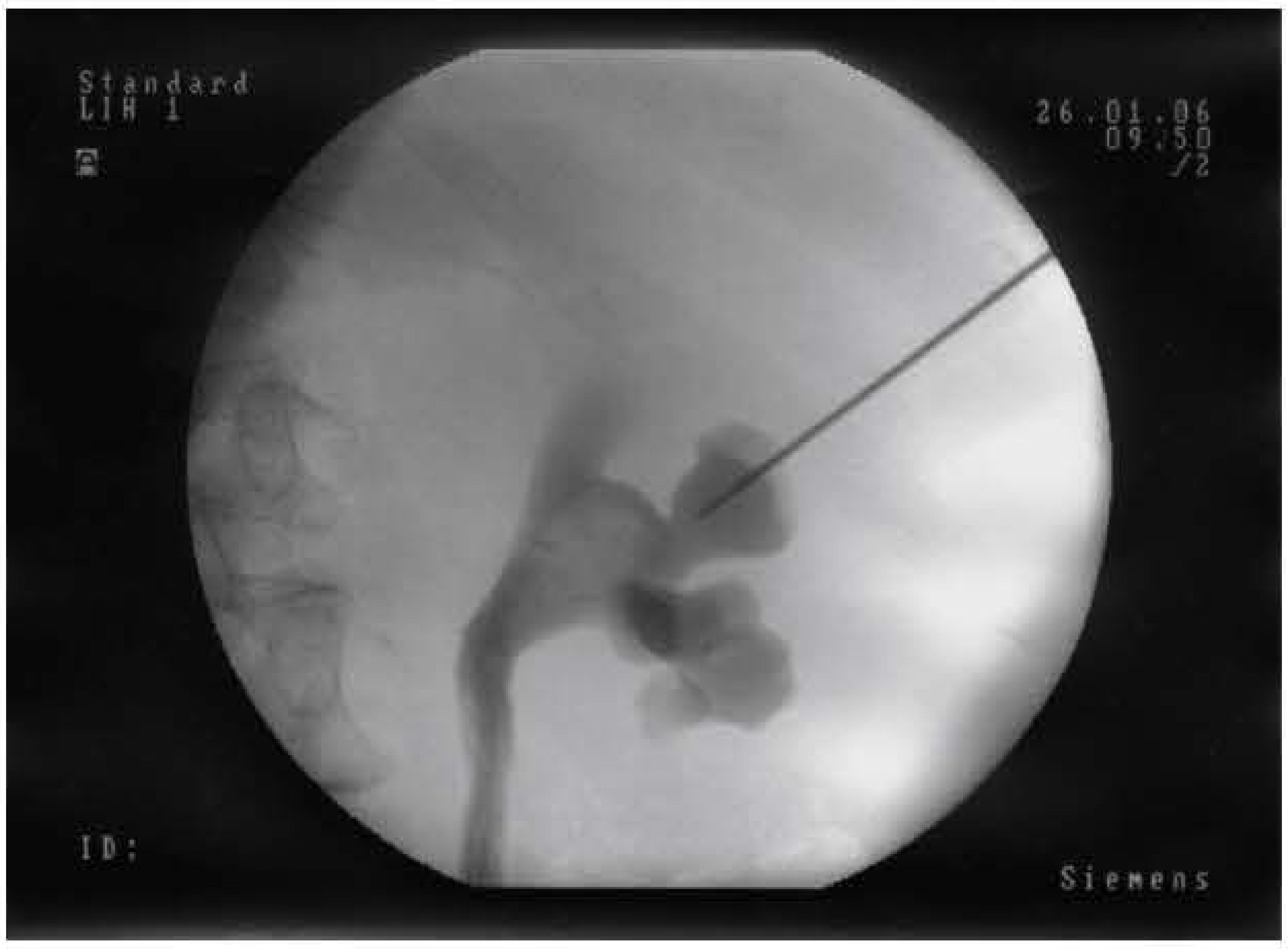

FIGURE 2.1 **Renal puncture under fluoroscopic guidance during PCNL.**

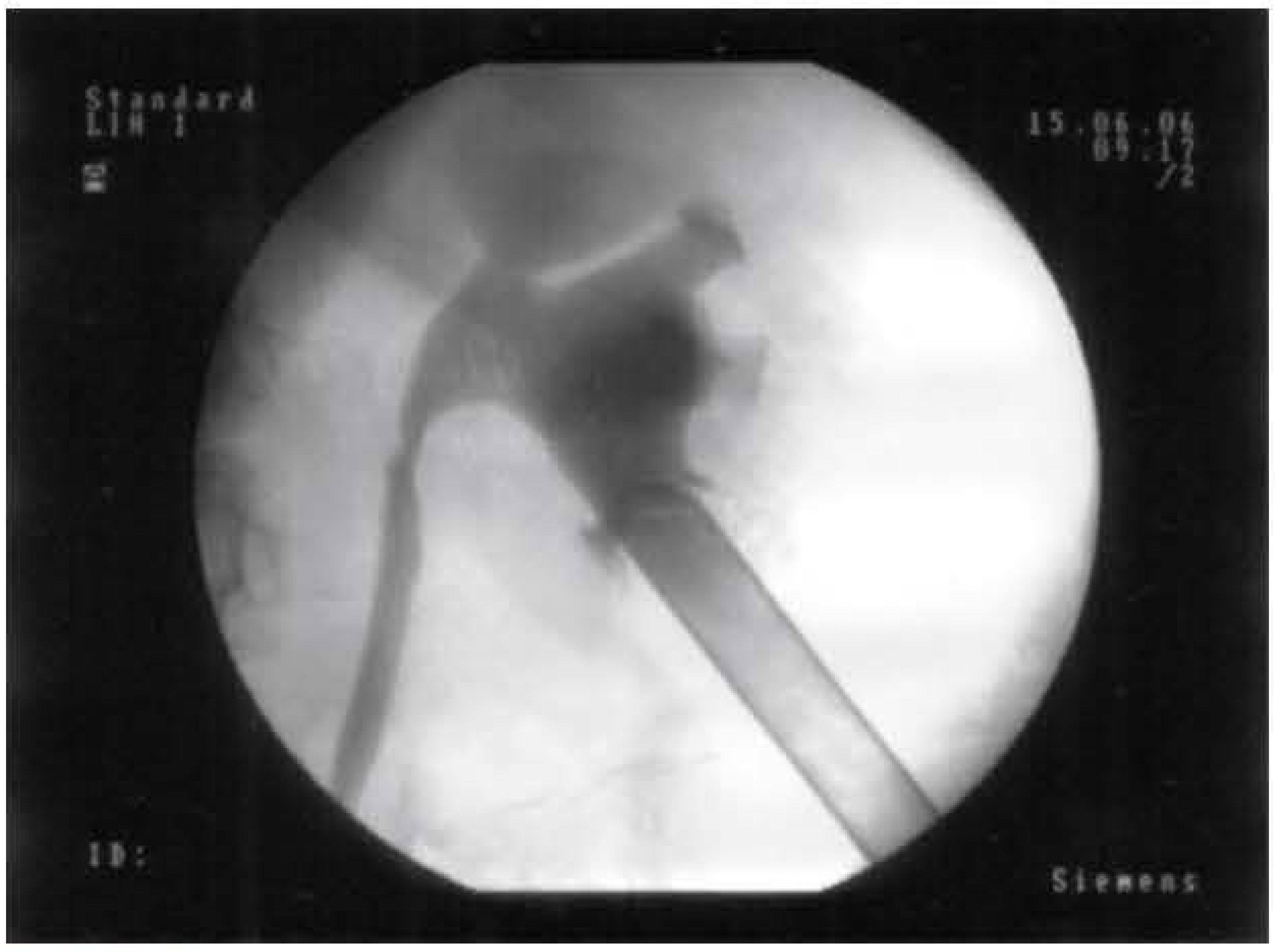

FIGURE 2.2 **Fluoroscopic evaluation at the end of PCNL.**

percutaneous approach in optimal conditions. It also allows an accurate assessment of the urinary tract's anatomy, as well as the identification of stenosis areas, calculi, and filling defects.

Fluoroscopy is necessary for monitoring the guidewire's ascent, the placement of the stent, or the dilation of the nephrostomy tract. At the end of the procedure, fluoroscopic visualization is necessary to detect possible residual stone fragments or undetected lesions of the pyelocaliceal system (Fig. 2.2). At the end of the intervention, the nephrostomy tube is also positioned under fluoroscopic guidance.

2.1.3.1 Radiological Protection

Achieving the percutaneous nephrolithotomy (PCNL) tract under fluoroscopic guidance represents the technique preferred by most urologists, leading, however, to the increased exposure of the medical staff and of the patient to the harmful effects of radiations. In these conditions, the medical staff has the additional responsibility of ensuring, before the intervention, all protection measures necessary for minimizing the exposure to X-rays during PCNL (Kumar, 2008).

The protection protocol against radiations requires the surgeon to use 0.35–0.5-mm lead aprons and a thyroid collar, while only the protection aprons are necessary for the rest of the staff in the operating room. These measures reduce the transmission of radiations to the human body over 100 times, while the exposure of the reproductive system and of the thyroid is minimal (Majidpour, 2010; Kicken and Bos, 1995; Christodoulou, 2003). The exposure of the hands can be diminished by using radioprotective gloves, which are avoided, however, by most urologists because they affect the accuracy of the surgeon's gestures.

The biologic effects after exposure to radiations can be generally classified into stochastic and deterministic effects. Deterministic effects occur only if a certain threshold irradiation dose is exceeded, and the severity of these effects increases in direct proportion with the dose. Cataract after exposure of the eye or cutaneous erythema are such examples. Consequently, an annual radiation dose limit has been established for certain organs with the role of protecting those exposed to professional radiation (Kumar, 2008). Stochastic effects have no dose threshold, and the relationship between the radiation dose and the effect is of a probabilistic type. The probability of the effect occurring increases with the dose. The occurrence of cancer or genetic disorders in descendants are examples of stochastic effects. It is obvious from the previous definitions that the lower radiation doses generally encountered in most diagnostic procedures cannot exceed the threshold dose established for deterministic effects, but there is the probability (although reduced) for the occurrence of stochastic effects (Kumar, 2008).

Disseminated radiation, resulting from the interaction of the primary rays generated by the fluoroscope with the patient and with the operating table, contributes to the increased exposure of the staff, especially those situated near the fluoroscopy unit (Majidpour, 2010).

Exposure to the radiations in the air is measured in Roentgen units, noted with "R." The dose absorbed by an organ or skin is measured in rad (radiation absorbed dose), 1 rad being equivalent to 100 erg of energy deposited in 1 g of tissue (Kumar, 2008). The international unit for the rad is the gray (Gy), 1 Gy being equal to 100 rad. However, the effects of radiations also depend on their ionizing properties. Thus, certain types of alpha radiations, such as the rays emitted by a radioactive material, are much more ionizing than other X-rays. For this reason, a radiation weighting factor has been assigned to all ionizing waves. Taking into account this factor, the amount of radiation is called equivalent dose and represents the absorbed dose multiplied with the radiation weighting factor. The measurement unit for the equivalent dose is the sievert (Sv). X-rays have a weighting factor of 1 and therefore the absorbed dose (Gy) is equal to the equivalent dose (Sv). On the other hand, the human organs are different regarding the sensitivity to radiation and therefore a tissue weighting factor is used for comparing the radiation dose for the entire body and for different organs. When organ sensitivity is taken into consideration, the amount of radiation is called the effective dose and it is calculated by multiplying the equivalent dose with the tissue weighting factor. The measurement unit for the effective dose is also the sievert.

The International Commission on Radiological Protection (ICRP) recommends an effective dose of 20 mSv per year, over an average defined period of 5 years, as the occupational threshold dose (Kumar, 2008). Similarly, for exposed personnel the ICRP recommends an annual threshold of the equivalent dose of 150 mSv for the eye and of 500 mSv for the skin and extremities. Instead, there is no recommended threshold dose for patients exposed to interventional or therapeutic radiologic procedures, with the condition that this practice is justified by medical benefits which are much greater than the risks of radiation exposure. However, both for the patients and staff, the radiation dose should be decreased as low as reasonably achievable (ALARA).

Achieving a level of irradiation close to zero according to the ALARA principle is not reasonable (having in mind the omnipresent background radiation), is prohibitively expensive, difficult, and can negate the potential benefits for patients. Instead, a judicious and prudent approach regarding the use of radiations in medicine is always justified. Therefore, besides the already-mentioned protection equipment, there are a number of measures that can additionally contribute to reducing the exposure of the medical staff and patients to radiation. Angiography devices used during cardiovascular and hepatobiliary interventions, diagnostic or therapeutic, work with fluoroscopic impulses instead of continuous fluoroscopy, significantly reducing the radiation dose.

The use of pulsed fluoroscopes during radiologically guided urologic interventions may be an additional measure for radioprotection. Some studies have demonstrated that a correct collimation of the radiation field, using curtains or radiation shields as well as suspended leaded glass panels, contributes to reducing the radiation dose for the patient and personnel (Kumar, 2008). Other measures for preventing prolonged exposure to radiations during interventions consist of displaying in real time the duration of the fluoroscope's use, the total radiation dose value per area unit, and the estimated dose to the skin (Kumar, 2008).

2.2 NEPHROSCOPES

2.2.1 Rigid Nephroscopes

The rigid nephroscope is an optical instrument which allows one to inspect the renal cavitary system and to perform different therapeutic procedures under direct visual control. Two models of nephroscopes have been described: the Wickham model (Fig. 2.3), with the telescope forming an angle of 130° with the sheath, and the Amplatz model (Fig. 2.4), with the telescope forming a 90° angle with the sheath. It consists of the external sheath and the working element. This contains the optical system and a working channel located in the central axis of the nephroscope, which allows insertion of the lithothripter or different working elements (stone forceps, extraction probe, etc.). The same axial channel also ensures the irrigation fluid's flow. The fluid returns through the space between the nephroscope and its sheath.

The rigid nephroscope introduced by the Storz company in 1965 (Pearson, 1975) was the first instrument used for viewing the pyelocaliceal system, and the nephroscope with optical fibers and round lenses was for a long time the standard instrument for renal percutaneous surgery (Anon, 2005).

Commonly used rigid nephroscopes have diameters of up to 28 F that ensure maximal working channels and irrigation.

The 26 F standard instruments ensure a very good visibility, allowing the use of a wide range of rigid accessories. Also, continuous irrigation through the endoscope has a flow sufficient for maintaining the pyelocaliceal system distended during the procedure. The evacuation of the washing fluid through the Amplatz sheath allows for an easy removal of the fragments resulting during lithotripsy and of the cloths, maintaining a clear visual field. Also, the increased irrigation flow allows the dissipation of the heat generated during stone fragmentation. Another important element ensured by this type of irrigation and evacuation of the washing fluid is that a low pressure is maintained in the urinary tracts, thus reducing the risk of pyelo-renal reflux and implicitly of fluid absorption and of septic dissemination (Gupta and Katsumi, 2012).

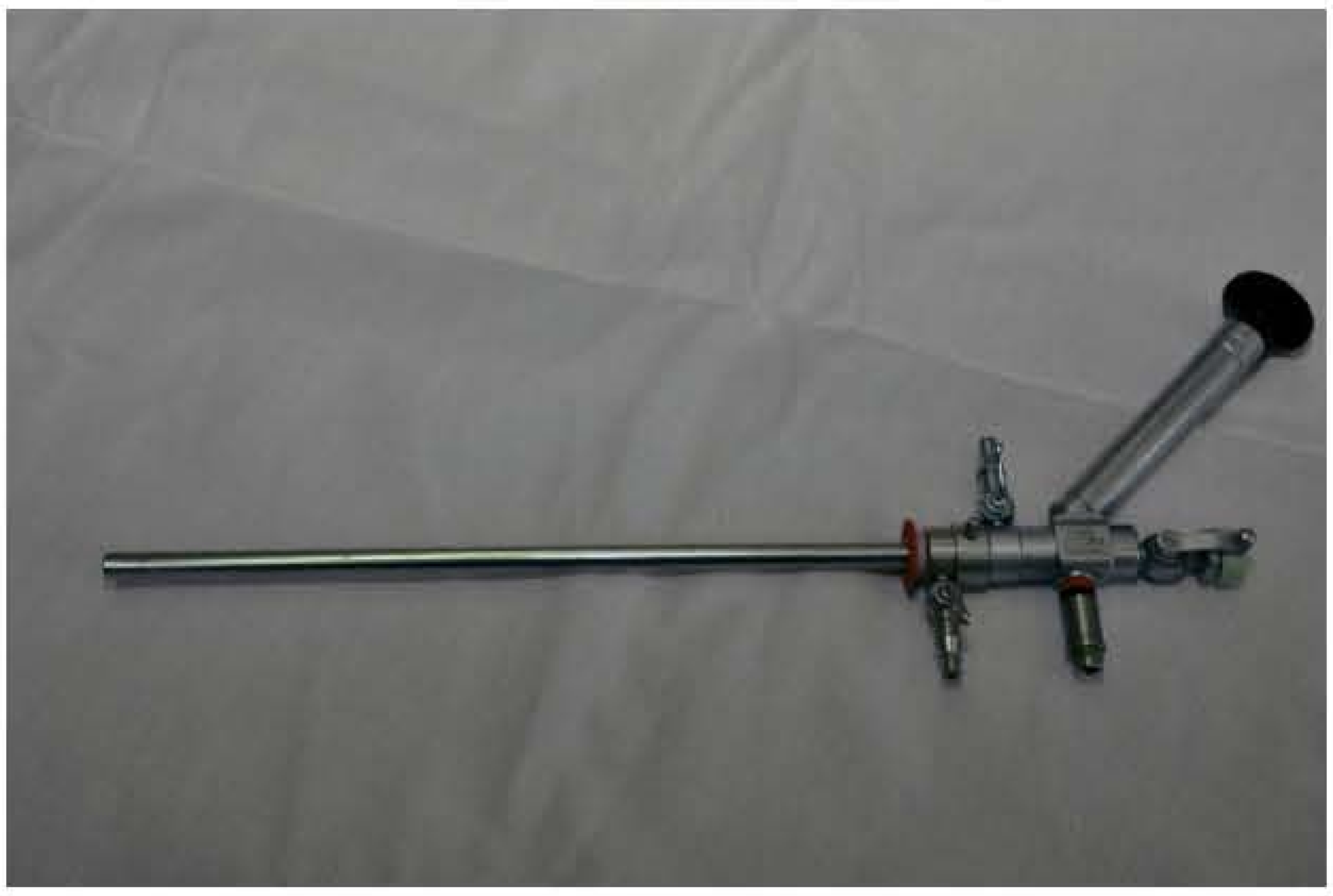

FIGURE 2.3 **The Wickham-type rigid nephroscope.**

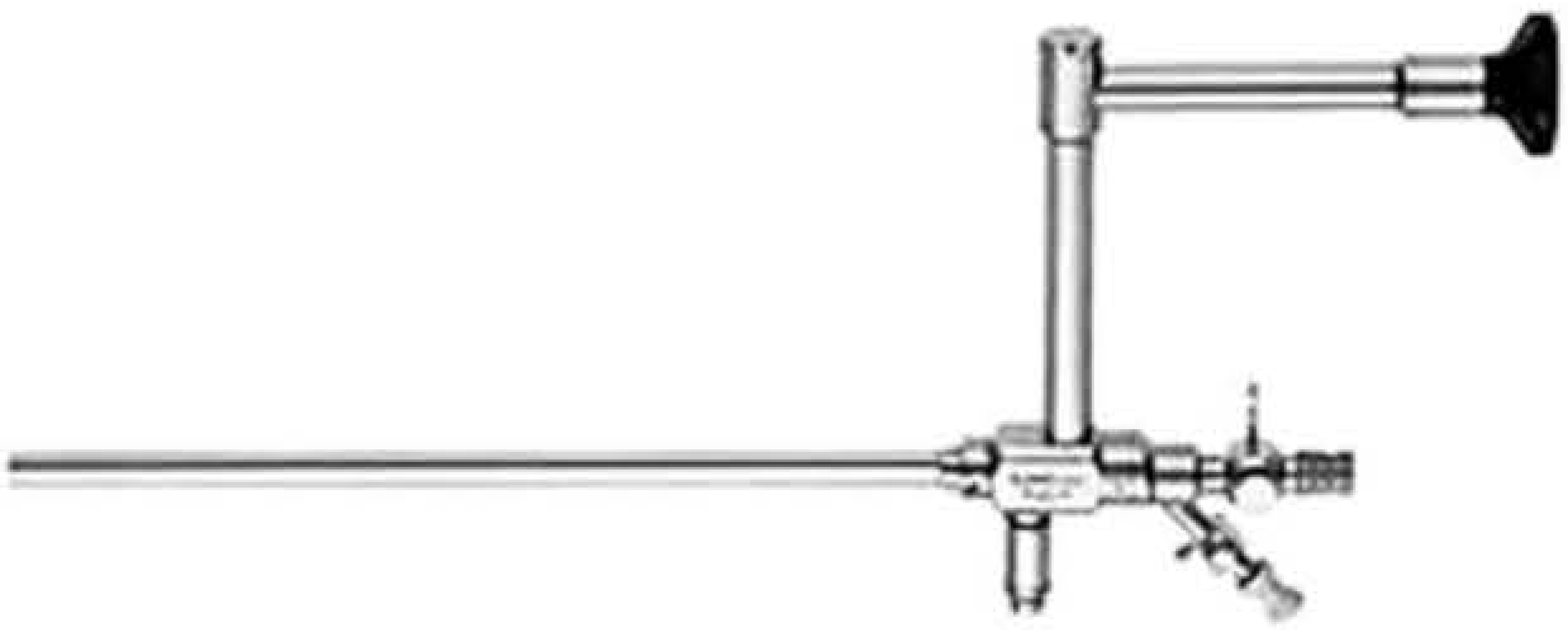

FIGURE 2.4 **The Amplatz-type rigid nephroscope.**

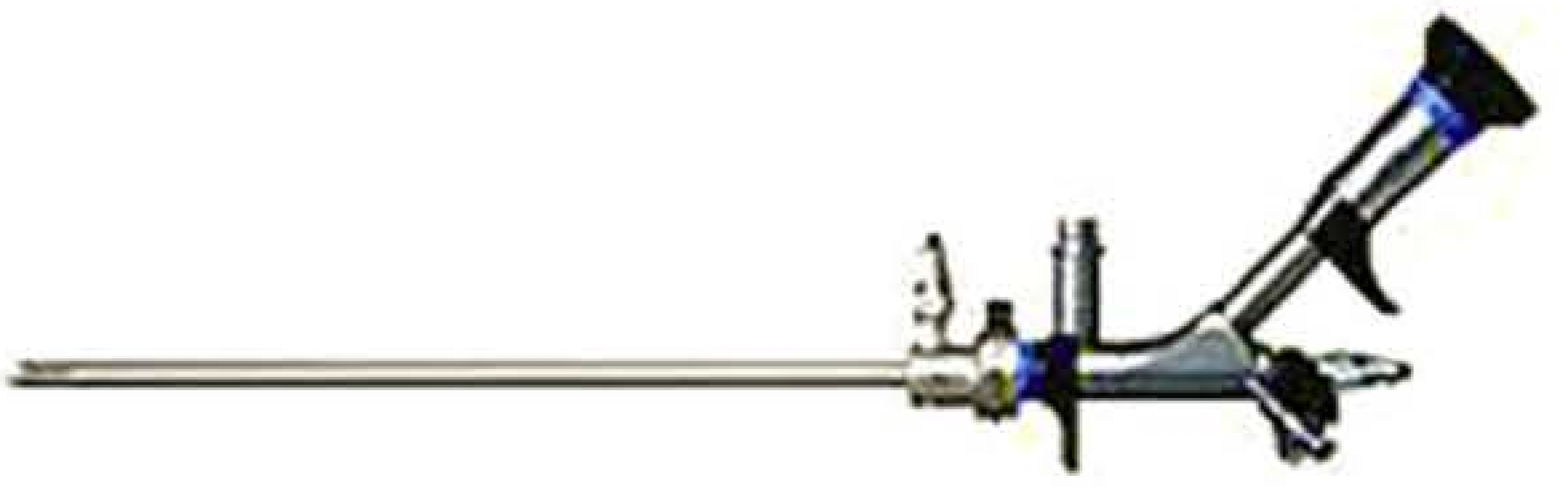

FIGURE 2.5 **A 15 F mini-nephroscope.**

Nephroscopes with smaller diameters, ranging between 11 F and 18 F (Fig. 2.5), are used for mini-PCNL (mini-perc). The term "mini-perc," although not precisely defined, includes interventions performed with nephroscopes which are thinner than the standard ones. Their use also implies the existence of a lower caliber working channel.

The mini-perc was found to be associated with lower morbidity compared to standard PCNL. Thus, a recent study (Resorlu et al., 2011) on the use of nephroscopes of different calibers in hypertensive patients showed that nephroscopes with a reduced caliber offer a similar efficiency and safety compared to the classic intervention, with the advantage of a shorter hospitalization and a lower rate of bleeding.

However, no benefits were observed regarding the preservation of renal parenchyma by using this technique (Desai et al., 1999; Feng et al., 2001; Gupta, 2007).

The use of the mini-perc in adults is still a controversial subject. On the other hand, this technique is considered elective for the percutaneous treatment of kidney stones in children (Desai et al., 1999; Feng et al., 2001).

However, there are reports in the literature supporting the feasibility of PCNL using adult nephroscopes even in children under 5 years of age (Nouralizadeh et al., 2009).

An even more miniaturized variant is ultraminiperc, in which the tract is punctured with the "All-Seeing-Needle" and dilated up to 11–13 F (Desai et al., 2013). Nephroscopes (6 F) are then used through this access sheath (Fig. 2.6).

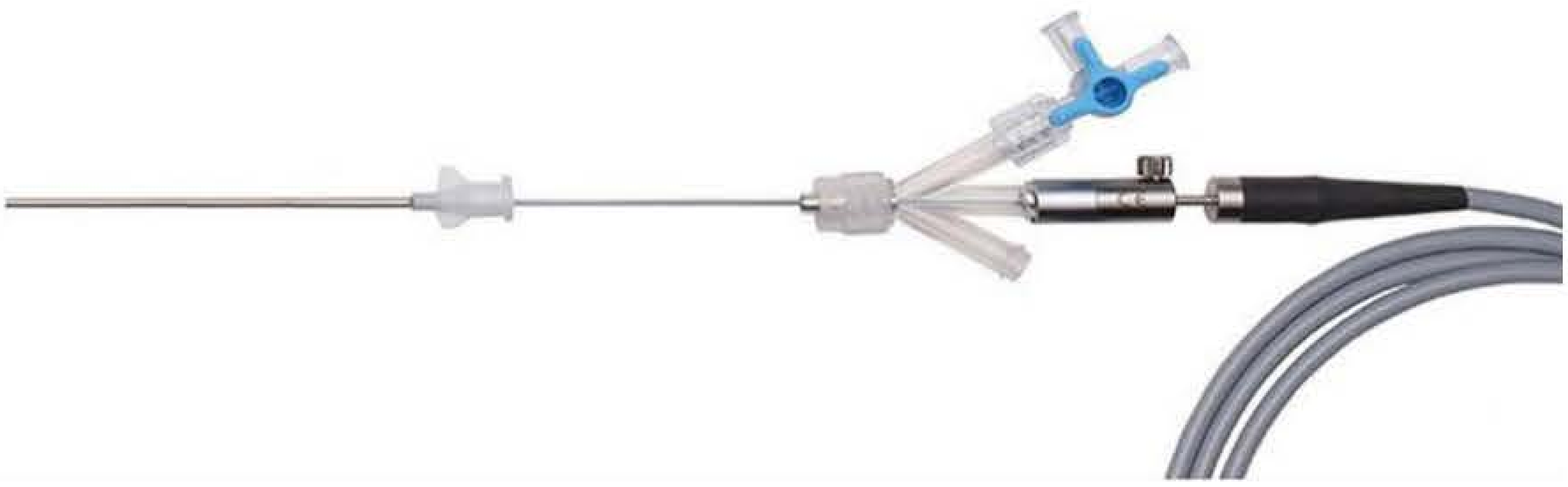

FIGURE 2.6 **"All-Seeing-Needle" (PolyDiagnost, Pfaffenhofen, Germany).**

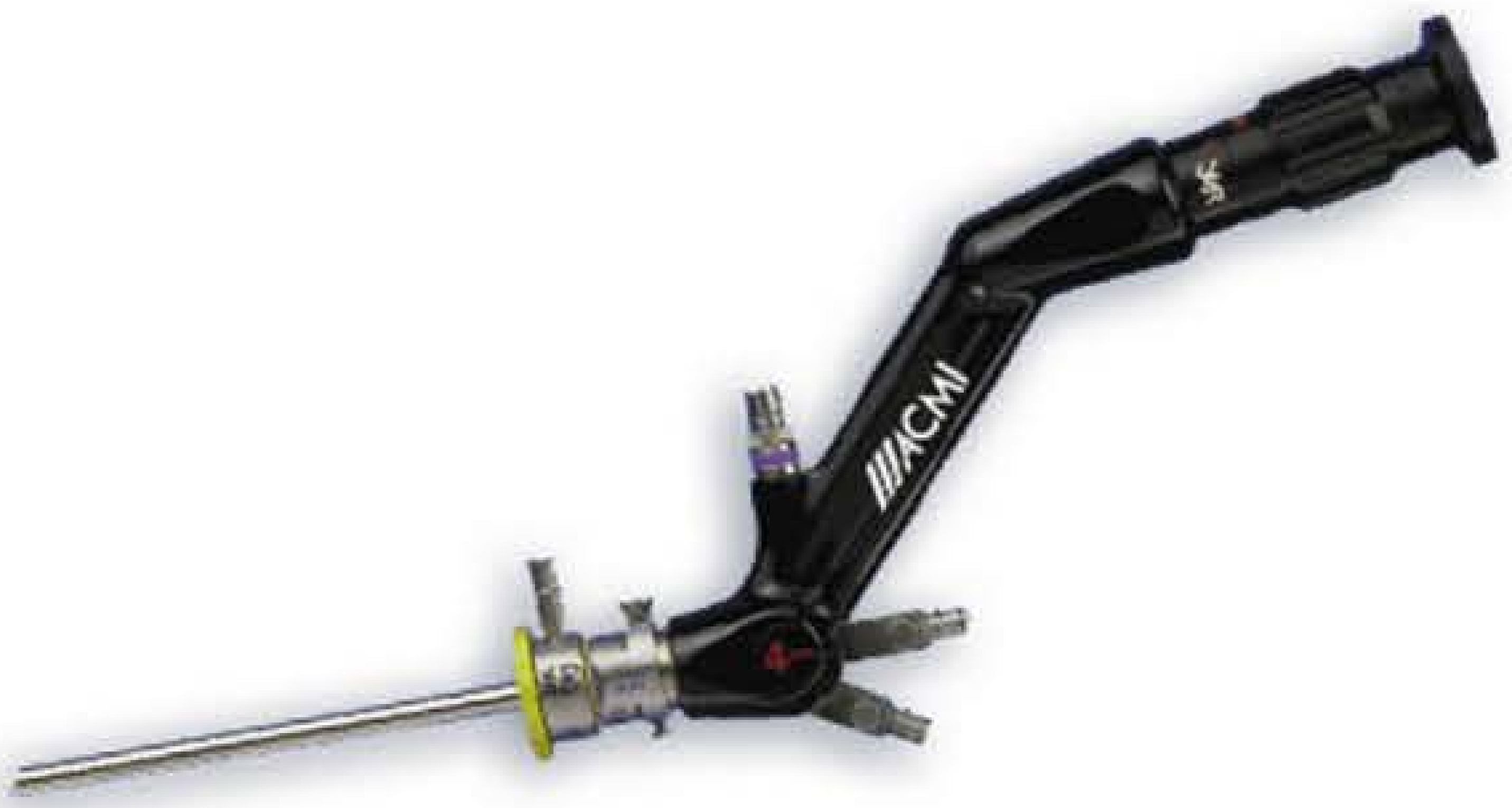

FIGURE 2.7 **Digital nephroscope.**

Microperc was first imagined by Desai et al. (2011), using a 4.85 F tract achieved with the "All-Seeing-Needle" (PolyDiagnost, Pfaffenhofen, Germany). This is a modified 4.85 F (1.6 mm) needle with a 0.9-mm micro-optic and an irrigation system, allowing puncture of the pyelocaliceal system under direct visual control.

The working hypothesis regarding this instrument is that achieving the perfect tract (avoiding viscera perforation and crossing the caliceal papilla) leads to a reduction in associated morbidity. Another advantage is represented by the fact that access is obtained in a single step, which translates into a shorter time between insertion and lithotripsy (Desai and Mishra, 2012).

Although they ensure a high image resolution, classic nephroscopes require an external camera and attachment of the cable from the light source, thus reducing maneuverability.

Technological progress from recent years has also materialized in the development of digital nephroscopes which increase the ergonomics of the instruments used. The Olympus Invisio® Smith digital nephroscope integrates the endoscope, the digital camera, and the light source into a "plug and play"-type device (Andonian et al., 2008), similar to the newly introduced nephroscopes developed lately (Fig. 2.7).

This nephroscope's weight is approximately half of the classic one (470 g vs. 939 g) and is longer than the standard ones (18 cm vs. 15 cm). At the distal end there is a 1-mm digital camera, the light being ensured by two LEDs, without requiring an external xenon light source. *In vitro* comparison with optical fiber nephroscopes showed that the digital image has a higher resolution (Ahmed et al., 2009; Vejdani et al., 2009), while the 4.9-mm (15 F) working channel allows the use of a wide variety of instruments, forceps, lithotripsy, or aspiration probes. It even allows insertion of a flexible ureteroscope through the working channel, with which lithiasic fragments located in areas that are difficult to access with the nephroscope can be extracted (Gupta and Katsumi, 2012).

Globally, this new generation of digital nephroscopes offers a more ergonomic design and a higher image resolution compared with those that are based on optical fibers. Although the first assessments are promising, additional studies are necessary to evaluate the cost–benefit ratio and to define their practical utility (Pugh and Canales, 2010).

2.2.2 Flexible Nephroscopes

A series of such flexible nephroscopes is currently marketed, produced by various companies, and most of them can be used both during percutaneous interventions and for the diagnosis and treatment of bladder conditions (cystonephroscopes). Their technical characteristics are quite diverse, but fit into certain general principles (Tables 2.1 and 2.2). The common structure of a flexible nephroscope includes a working channel, the deflection mechanism, and three bundles of optical fibers surrounded by an external sheath (Fig. 2.8).

2.2.2.1 External Configuration

Most of the existing models have a cylindrical, smooth, working distal part with a diameter of approximately 15 F (5 mm) at the tip.

2.2.2.2 Deflection Mechanism

Most of the models have a single active bidirectional deflection, obtained by acting on a mobile piece of the nephroscope's body (Fig. 2.9).

The amplitude of the deflection varies by model, between 120° and 210°, usually being asymmetrical in the two directions.

TABLE 2.1 Technical Characteristics of Some Models of Conventional Flexible Cystonephroscopes

Manufacturer	Model	Diameter	Working channel	Visual field (°)	Deflection (up/down) (°)
ACMI	ACN-2	14.6 F (4.8 mm) at the tip	6.4 F (2.1 mm)	110	180/170
Olympus	CYF-5	16.5 F (5.5 mm)	7.2 F (2.4 mm)	120	210/120
Richard Wolf	Flexible Fibre Urethro-Cystoscope	15 F (5 mm)	7.5 F (2.5 mm)	120	210/150
Karl Storz	11272CU1	15 F (5 mm)	7 F (2.3 mm)	110	210/140

TABLE 2.2 Technical Characteristics of the Models of Digital Flexible Nephroscopes Currently Manufactured

Manufacturer	Model	Optic system	Light system	Diameter	Visual field (°)	Working channel	Deflection (up/down) (°)
ACMI	Invisio (ICN)	Digital (CMOS)	LEDs	15 F (5 mm) 14.6 F at the tip	110	6.4 F (2.1 mm)	N/A
ACMI	DCN-2010/2030	Digital	LEDs	18 F (6 mm)	110	6.4 F (2.1 mm)	200/180
Richard Wolf	Wolf EyeMax CCD	Digital (CCD)	External source	15.9 F (5.3 mm) 9.8 F at the tip	120	6 F (2 mm)	210/150
Olympus	CYF-V2/VA2 EndoEYE	Digital (CCD)	External source	16.2 F (5.4 mm)	120	6.6 F (2.2 mm)	210/120

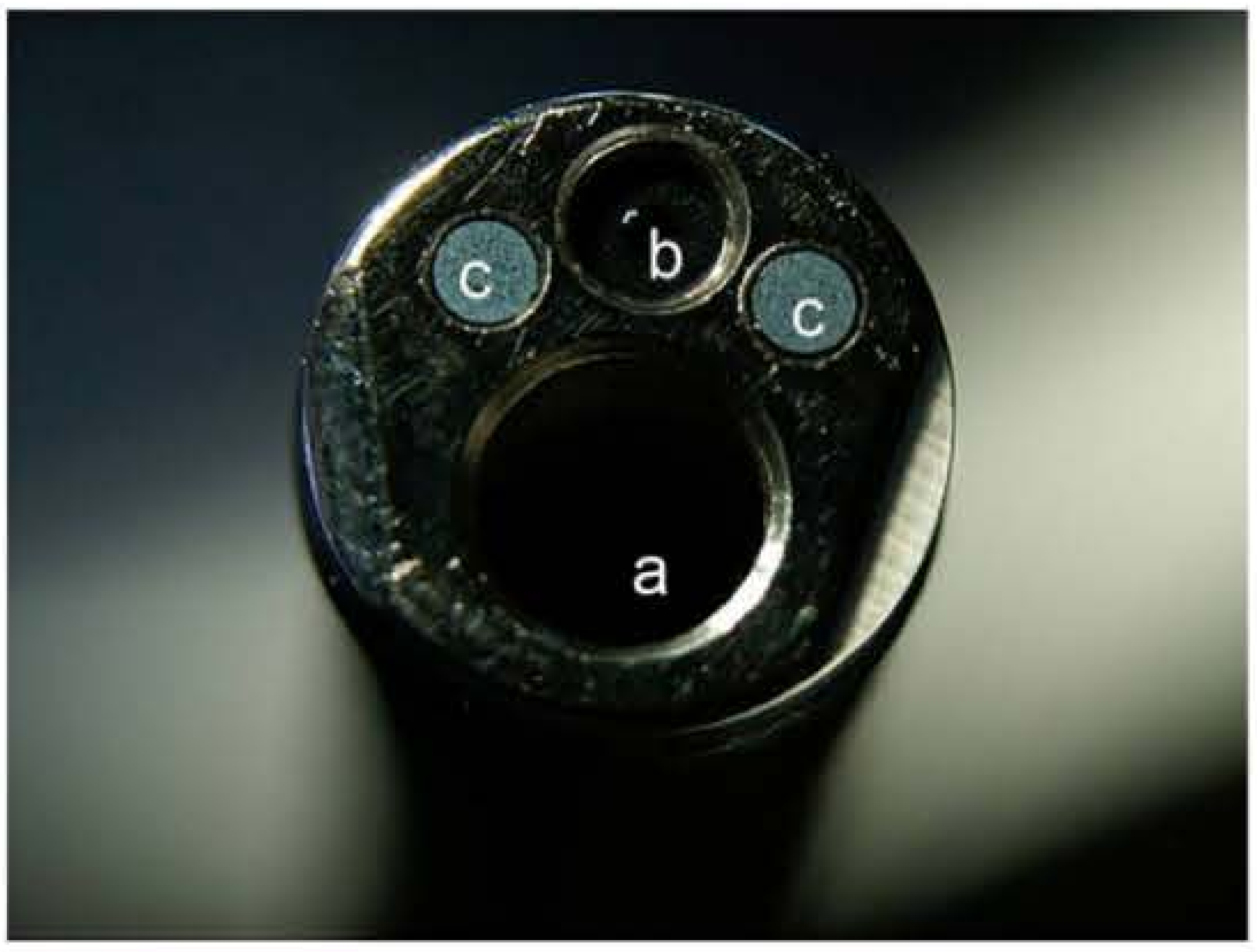

FIGURE 2.8 **The structure of a flexible fibro-nephroscope.** (a) Working channel, (b) coherent optical fiber bundle for image transmission, and (c) noncoherent optical fiber bundles for light transmission.

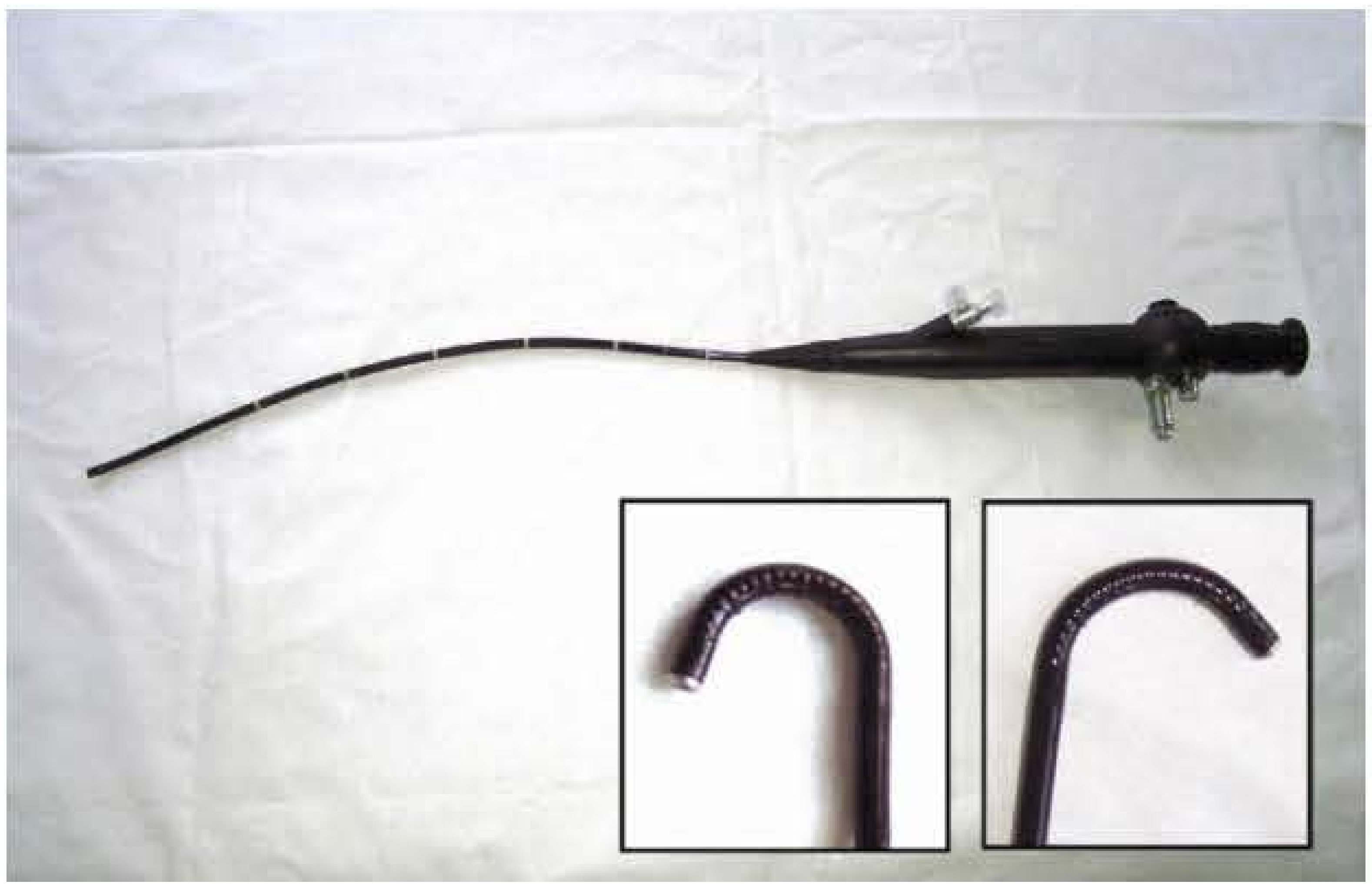

FIGURE 2.9 **Storz 11272CU1 flexible nephroscope.**

The ACMI DCN-2010/2030 model (ACMI Corporation, Southborough, MA, USA) has two active deflections in two different planes, sagittal and frontal (four flexion directions or orthogonal deflection), offering a greater maneuverability at the pyelocaliceal level (Fig. 2.10).

2.2.2.3 Optical and Light Transmission System

The optical fibers of the three fascicles allow the accurate transmission of light and images over long distances, thanks to the internal optical reflection phenomenon described in flexible ureteroscopes.

Of the three fascicles of optical fibers, two have a noncoherent structure (for light transmission) and one has a coherent structure (for image transmission). The coherent bundle is formed from thousands of glass fibers of

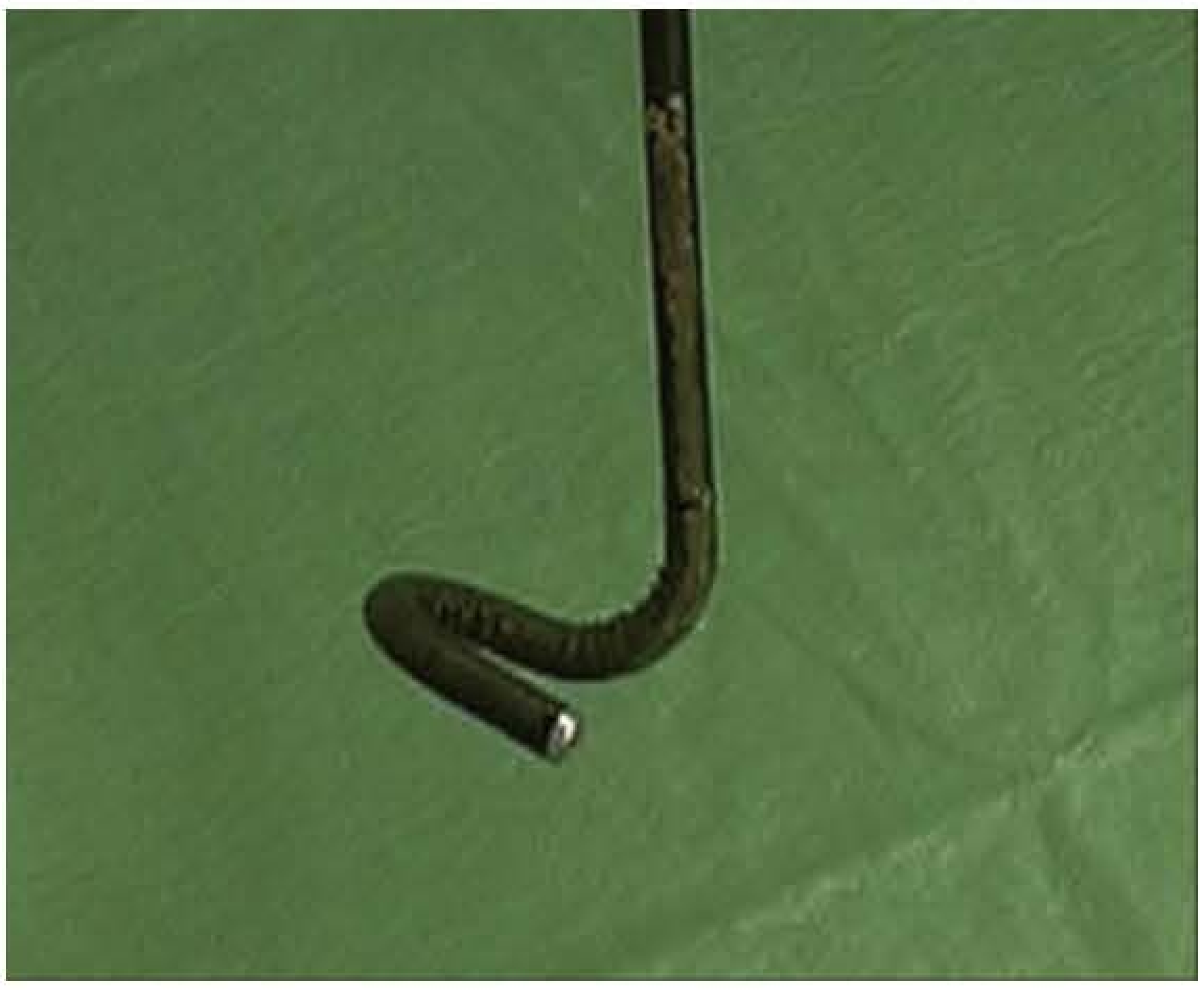

FIGURE 2.10 **Orthogonal deflection of an ACMI DCN-2010 flexible nephroscope (ACMI Corporation, Southborough, MA, USA).**

approximately 8 μm and has the essential property of their identical disposition at both ends, so that the image received at the distal end is transmitted identically to the proximal end, where it is captured by a video camera. Due to the conventional optic system's structure, the final image will have the honeycomb (moire) effect, a characteristic of flexible endoscopes. However, the fascicle's thickness and implicitly the higher number of optical fibers determine a better resolution and a wider endoscopic field than in flexible ureteroscopes.

This image has a lower resolution than that obtained through the optic system of rigid nephroscopes, but has sufficient quality to allow their efficient use during endourological interventions (Fig. 2.11).

In the recently developed digital flexible nephroscopes, this traditional optic system is replaced by a CCD or CMOS-type chip located at the distal end. The image is transmitted digitally through a single wire to a processor located proximally, which decodes, improves, and transmits the image to the monitor.

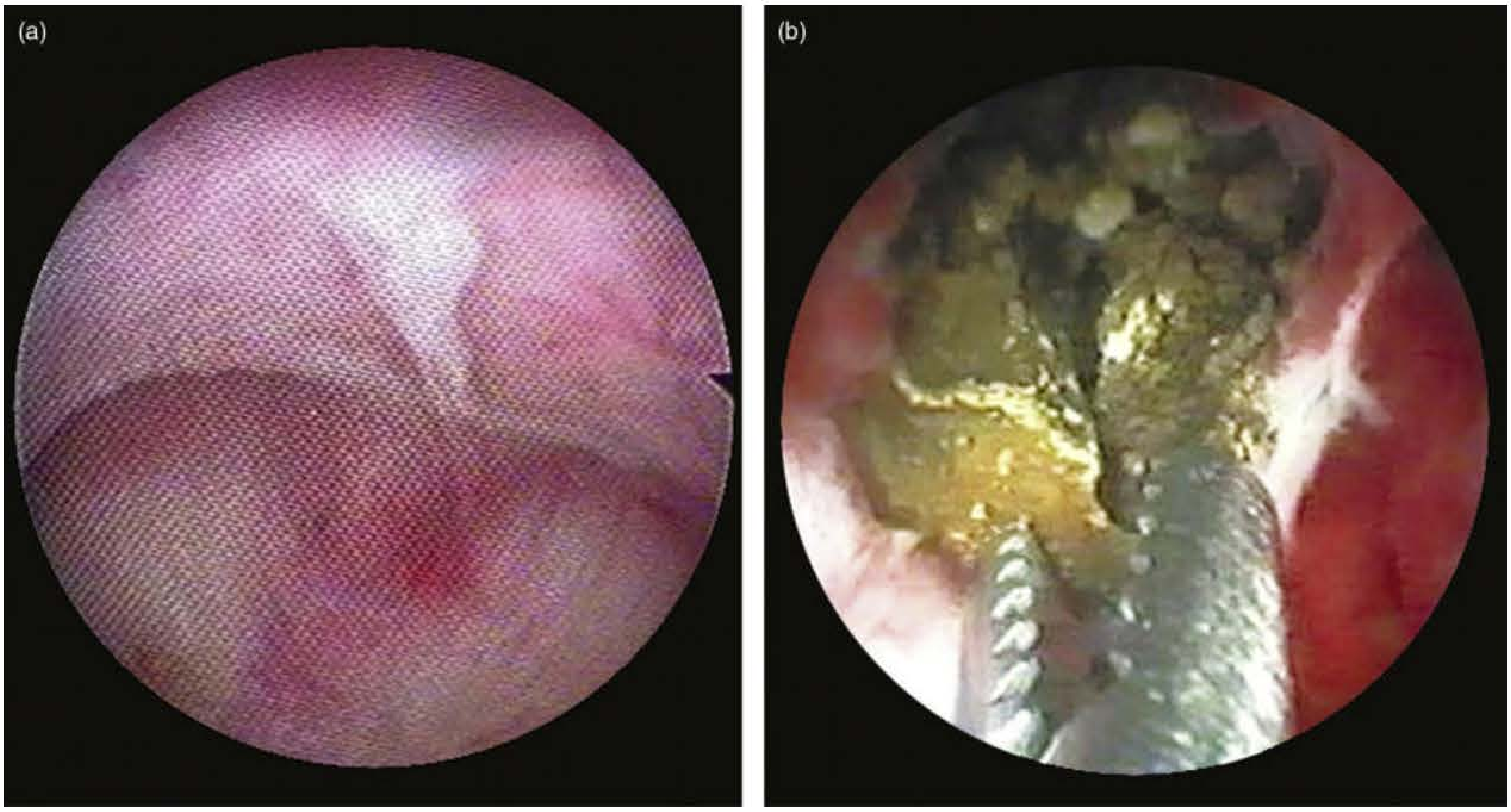

FIGURE 2.11 **Comparative aspects of image transmission by (a) conventional and (b) rigid flexible fibro-nephroscopes.**

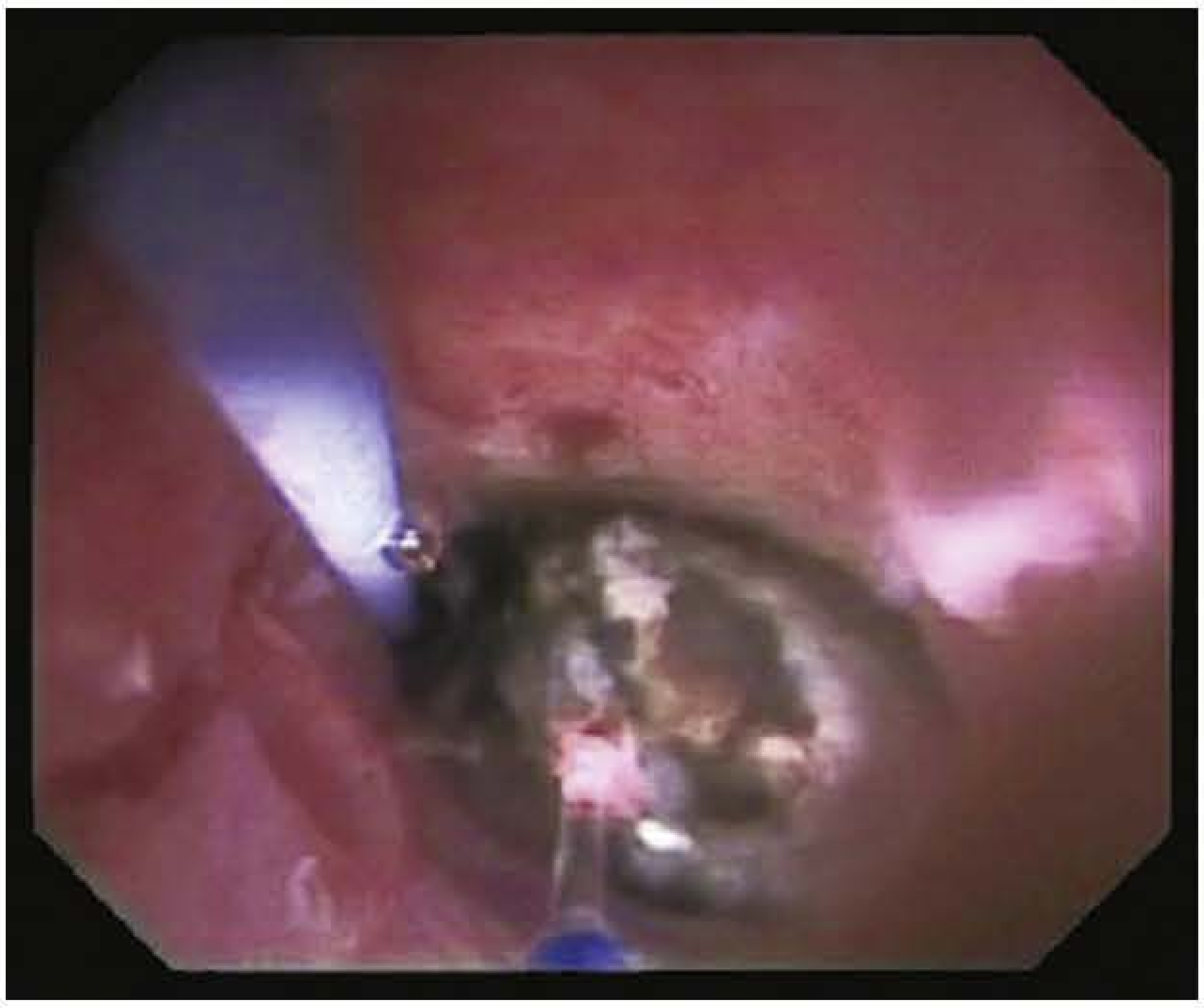

FIGURE 2.12 **Image obtained by an ACMI DCN-2010 digital flexible nephroscope (ACMI Corporation, Southborough, MA, USA).**

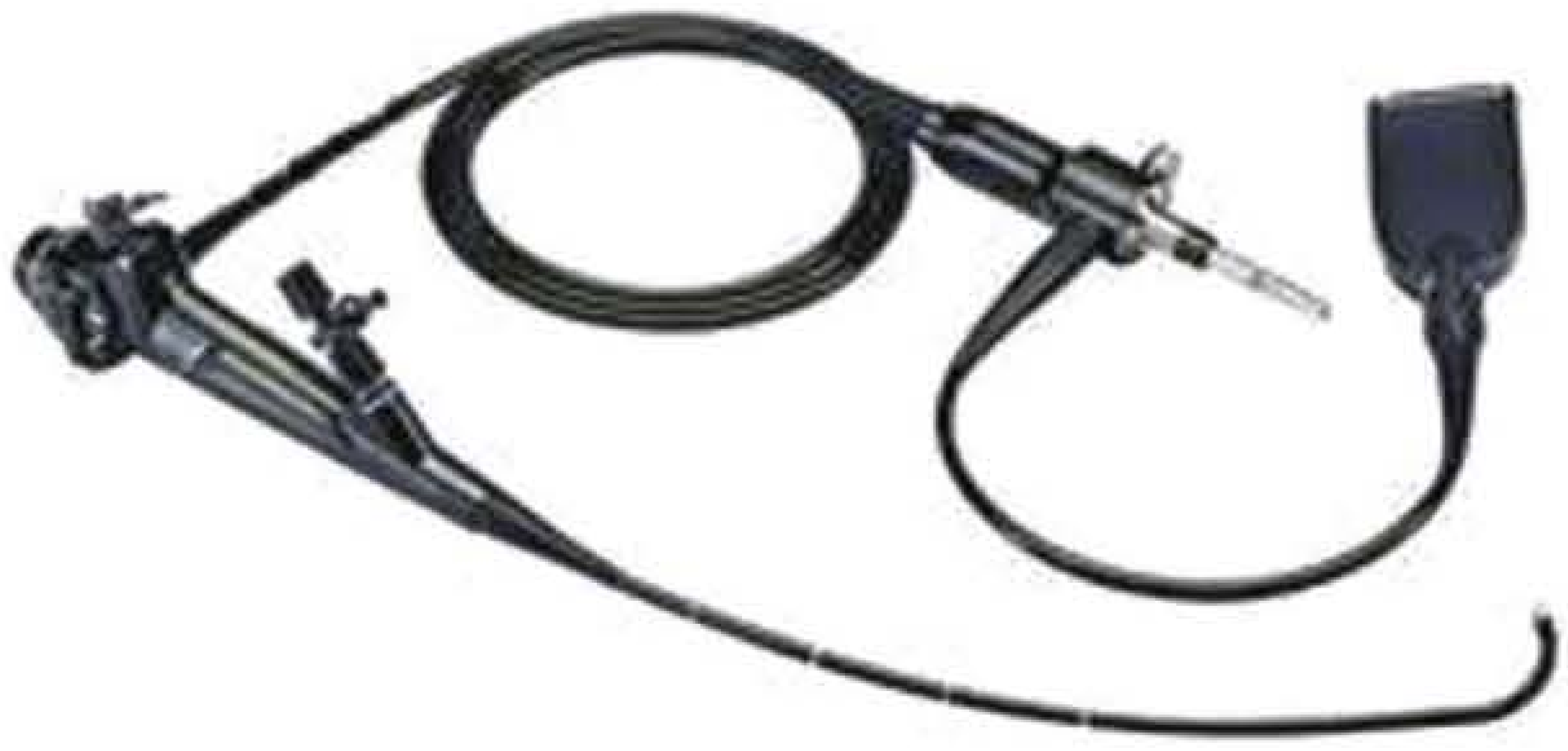

FIGURE 2.13 **Olympus CYF-VA2 digital flexible nephroscope (Olympus, Melville, NY, USA).**

Thus, the inconveniences of the classic optical system are overcome (distorted image, low resolution, honeycomb aspect) while maintaining the endoscope's flexibility (Fig. 2.12) (Quayle et al., 2005; Borin et al., 2006).

A number of such digital flexible nephroscopes are currently produced in: ACMI Invisio™ Flexible CystoNephroscope, ACMI DCN-2010/2030 (ACMI Corporation, Southborough, MA, USA), Olympus CYF-V EndoEYE, Olympus CYF-V2 (Olympus, Melville, NY, USA), Wolf EyeMax CCD (Richard Wolf, Knittlingen, Germany) (Figs. 2.13 and 2.14).

In addition, for the previously mentioned ACMI models, the noncoherent optical fiber bundles, used for light transmission, have been replaced by a system of white light LEDs positioned at the distal end of the nephroscope. Therefore, the conventional system of light transmission from the nephroscope, the separate light source, and the related cables are no longer necessary.

Studies that compared the performances of digital flexible nephroscopes to those of nephroscopes with conventional optic systems in terms of visibility demonstrated the superiority of the first ones regarding resolution, contrast, and differentiation of shades of red (Quayle et al., 2005; Borin et al., 2006).

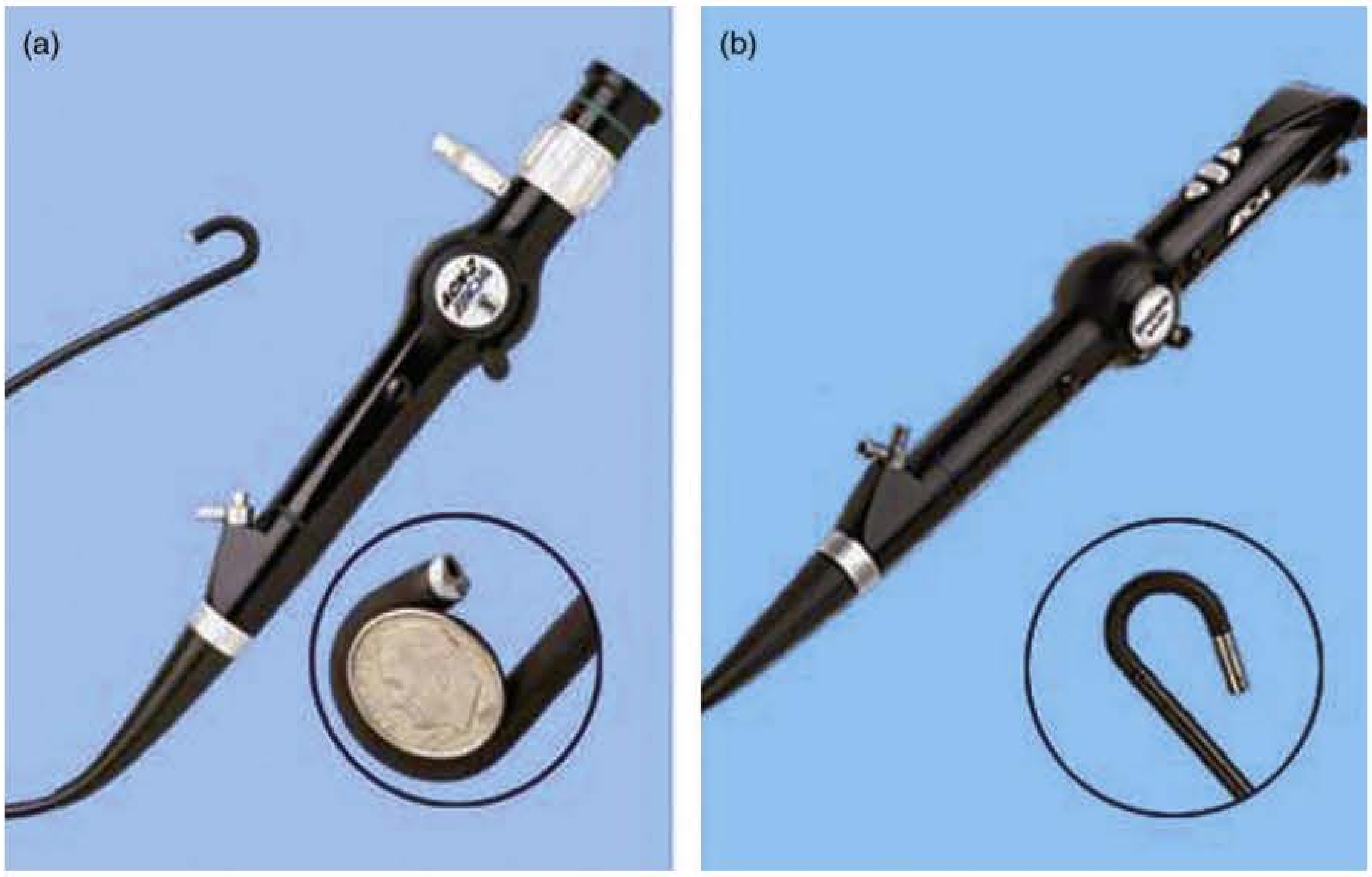

FIGURE 2.14 **(a) Conventional ACMI ACN-2 and (b) digital ACMI ICN flexible nephroscope (ACMI Corporation, Southborough, MA, USA).**

The Olympus CYF-VA2 model also presents the possibility for narrow-band imaging (NBI), described in previous chapters, which offers a potential advantage, especially in the case of inspection of the pyelocaliceal system for any malignant lesions.

Being developed relatively recently, digital endoscopes have not yet been fully evaluated regarding their durability. However, the removal of the fragile optical fiber bundles, as well as the proven reliability of the CCD and CMOS sensors (widely used for producing digital photo cameras, cell phones, and other electronic products), suggests that digital flexible nephroscopes will be more resistant than their conventional counterparts.

Another potential advantage is represented by the fact that the CCD or CMOS sensors are composed of silicon semiconductors, which are resistant to autoclaving temperatures. Thus, the premises for developing a digital flexible nephroscope that can be sterilized through this method are created (Quayle et al., 2005). Unfortunately, the price of these endoscopes is still very high.

2.2.2.4 Working Channel

The working channel is used for circulating the irrigation fluid, and for inserting accessory instruments as well as probes or energy source fibers. Its caliber varies between 6.4 F and 7.2 F (2.1 and 2.4 mm).

2.2.2.5 Particularities of Accessory Instruments

The video, irrigation, and guidance systems, the instruments necessary for achieving the percutaneous access as well as for performing/maintaining the nephrostomy tract, are the same for the interventions using rigid or flexible nephroscopes. In the case of flexible nephroscopy, notable differences appear regarding the energy sources, as well as the accessory instruments necessary for fragmenting and extracting the stones. These instruments must have a diameter small enough to be inserted through the working channel and enough flexibility so as not to prevent the useful deflection of the endoscope.

2.3 INSTRUMENTS USED FOR ACHIEVING THE PERCUTANEOUS TRACT

Creating a percutaneous tract implies obtaining access to the pyelocaliceal system, the dilation of this tract, and eventually the placement of a sheath to maintain its direction and caliber during the intervention, thus allowing an easy reapproach with different instruments. Unfortunately, this initial step of the interventions is also associated with the highest risk of potential lesions.

2.3.1 Otis Urethrotome

2.3.1.1 Puncture Needles

The needles used for puncturing the pyelocaliceal system (Fig. 2.15) consist of two or three coaxial pieces: central mandrel and sheath/sheaths. The central mandrel has oblique edges and exceeds the external sheath in length. The latter frequently has the end cut straight, so as not to damage the wall of the upper urinary tract after withdrawing the central piece (Fig. 2.16).

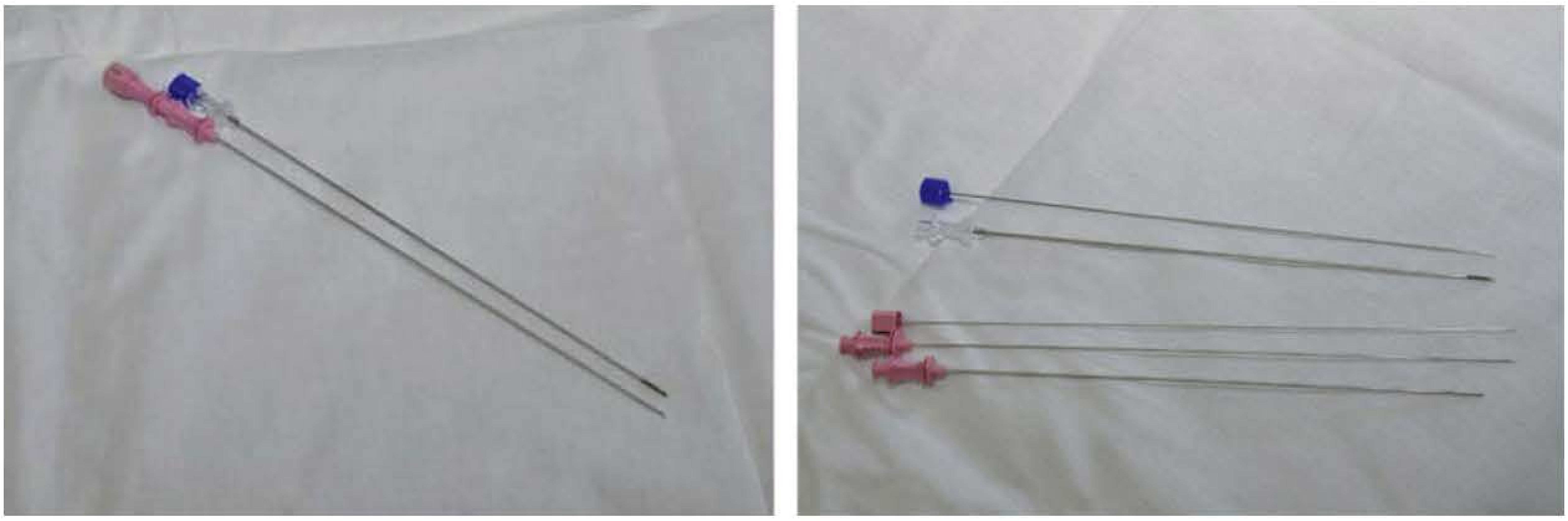

FIGURE 2.15 **Percutaneous puncture needles composed of two or three pieces.**

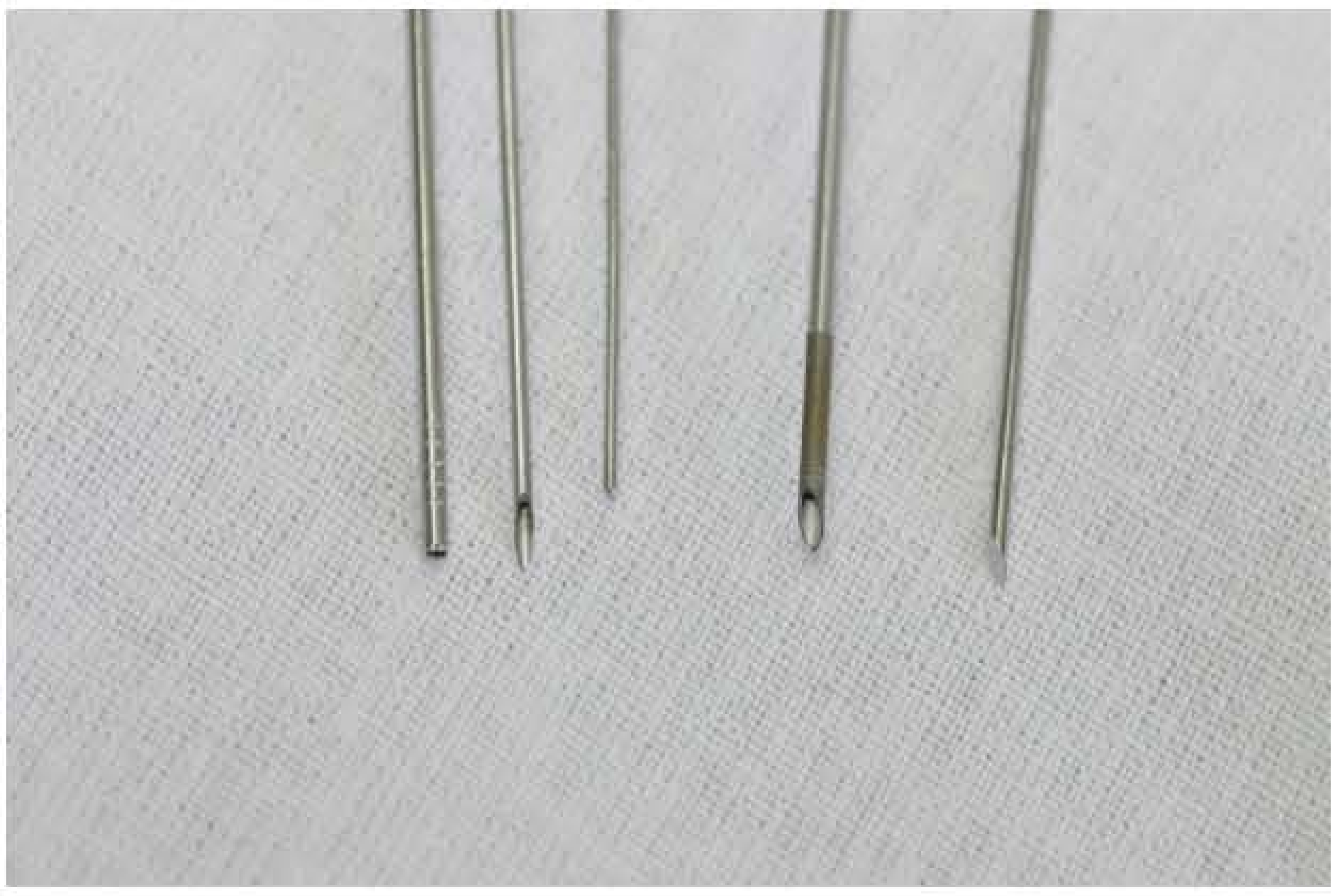

FIGURE 2.16 **Detail of the distal ends, with the external sheath cut straight (left) or with oblique edges (right).**

The needles most frequently used during percutaneous interventions have 18- or 21-gauge diameters. The 18-gauge needles, which are thicker, have the advantage of a greater axial rigidity, which allows for a better control of the direction of advancement when passing through the fascia. Also, they are easier to visualize when the intervention is carried out under fluoroscopic control. Thicker, 0.038–0.039-in. guidewires can be inserted through these needles.

The thinner 21-gauge puncture needles allow the insertion of 0.018-in. guidewires through them. Their advantages are represented by a potentially reduced aggressiveness against the renal parenchyma and a better adaptation to thin, undilated caliceal infundibula. Also, by using thinner guidewires, the risk of perforating the upper urinary tract is significantly reduced, even if an attempt is made to overcome an impacted stone or a stenosis area.

2.3.1.2 *Guidewires*

The guidewires used for percutaneous access have soft ends, usually in the shape of the letter J, to reduce the risk of perforation (Fig. 2.17). Also, with the exception of several centimeters at the end, their axial rigidity is increased. This property is important for allowing the various accessories (catheters, fascial dilators, coaxial metallic dilators, etc.) to slide without distorsion, because any such incident during the dilation maneuvers of the percutaneous tract can lead to its loss.

Guidewires have diameters varying between 0.018 in. and 0.039 in. As a general rule, the thinner the guidewire the less traumatic it will be, but unfortunately it will also be more deformable. The dilation of the puncture tract is usually performed on 0.038–0.039-in. guidewires with an increased axial rigidity (LeRoy, 2012).

Most of these guidewires are coated with Teflon, which ensures their increased axial rigidity. Guidewires with a hydrophilic coating are more rarely used during percutaneous interventions due to the increased risk of extraction or depositioning. They are useful when trying to negotiate tortuous tracts, impacted calculi, areas of stenosis, or

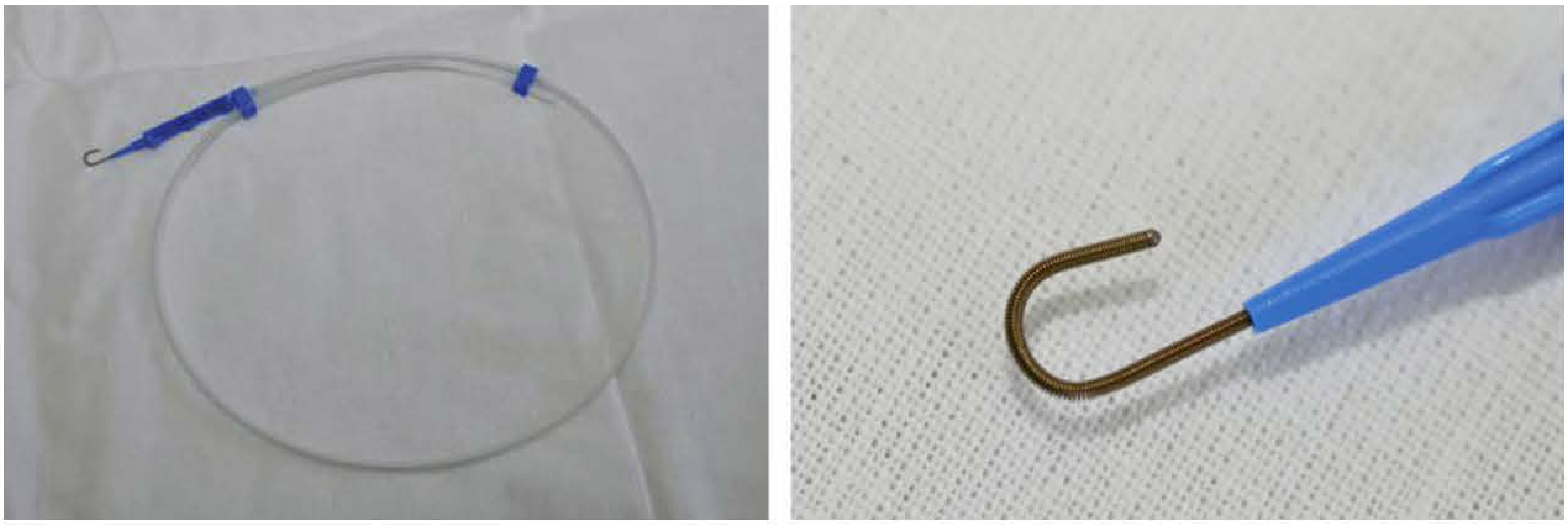

FIGURE 2.17 **J-end guidewire, used in percutaneous interventions.**

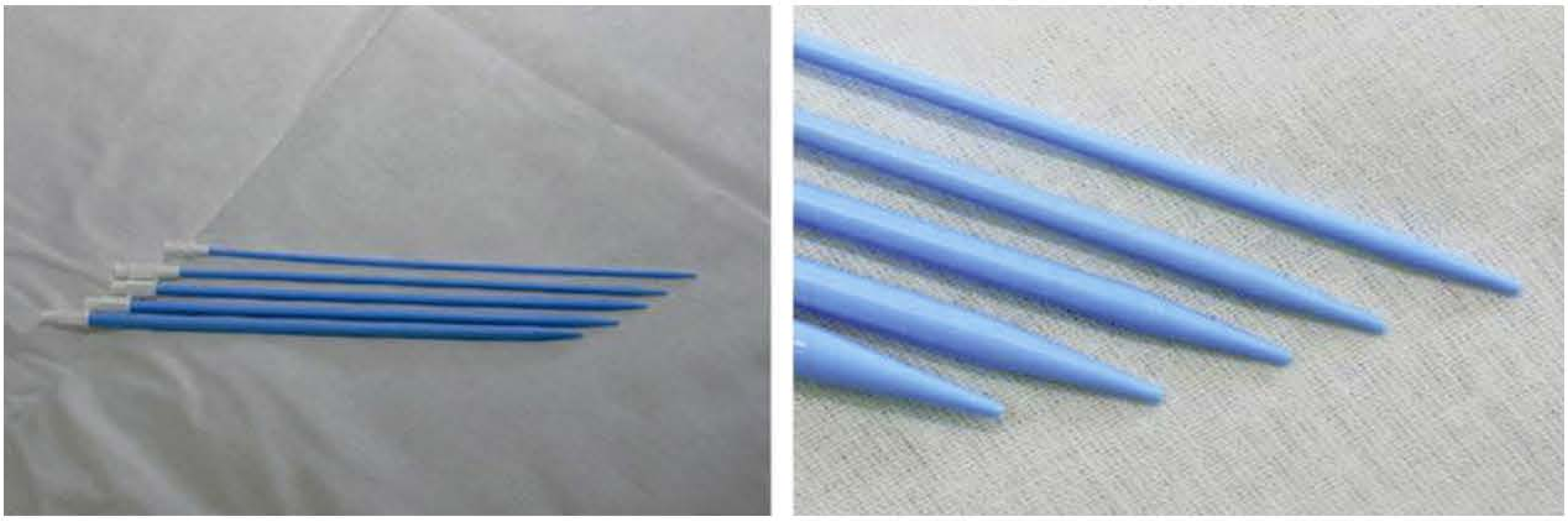

FIGURE 2.18 **Set of fascial dilators.**

edema. However, once the difficult area is overcome, it is recommended to replace the guidewire with a more rigid one. This is done on a catheter slid through the guidewire. The same method can also be applied for replacing a thin guidewire with a thicker one.

2.3.2 Devices Used for Tract Dilation

2.3.2.1 Fascial Dilators

Fascial dilators are conical pieces with calibers varying between 3 F and 30 F and a central channel to be slid on the guidewire (Fig. 2.18). These instruments are used for the initial dilation of the percutaneous tract. If the only purpose is to place a nephrostomy catheter, the dilation achieved by using them is usually enough.

Fascial dilators are relatively flexible devices and therefore, especially when trying to overcome dense connective structures or some cicatricial areas, there is the risk of the guidewire coiling in the perinephric fat, with the loss of the tract (Lynch et al., 1992). Also, the compressive forces exerted on the axial direction can theoretically break the parenchyma or vessels, causing bleeding which is sometimes dramatic. This disadvantage is characteristic to all dilation systems with the exception of the balloon one.

2.3.2.2 Lombotome

The lombotome (Fig. 2.19) is a device with a similar mode of use as the urethrotome. It is composed of a distal blade with a proximal handle and is designed to slide on the guidewire for a controlled advancement. This tool is used for the incision of the denser fascial tissue incision, thus ensuring an easy dilation of the tract.

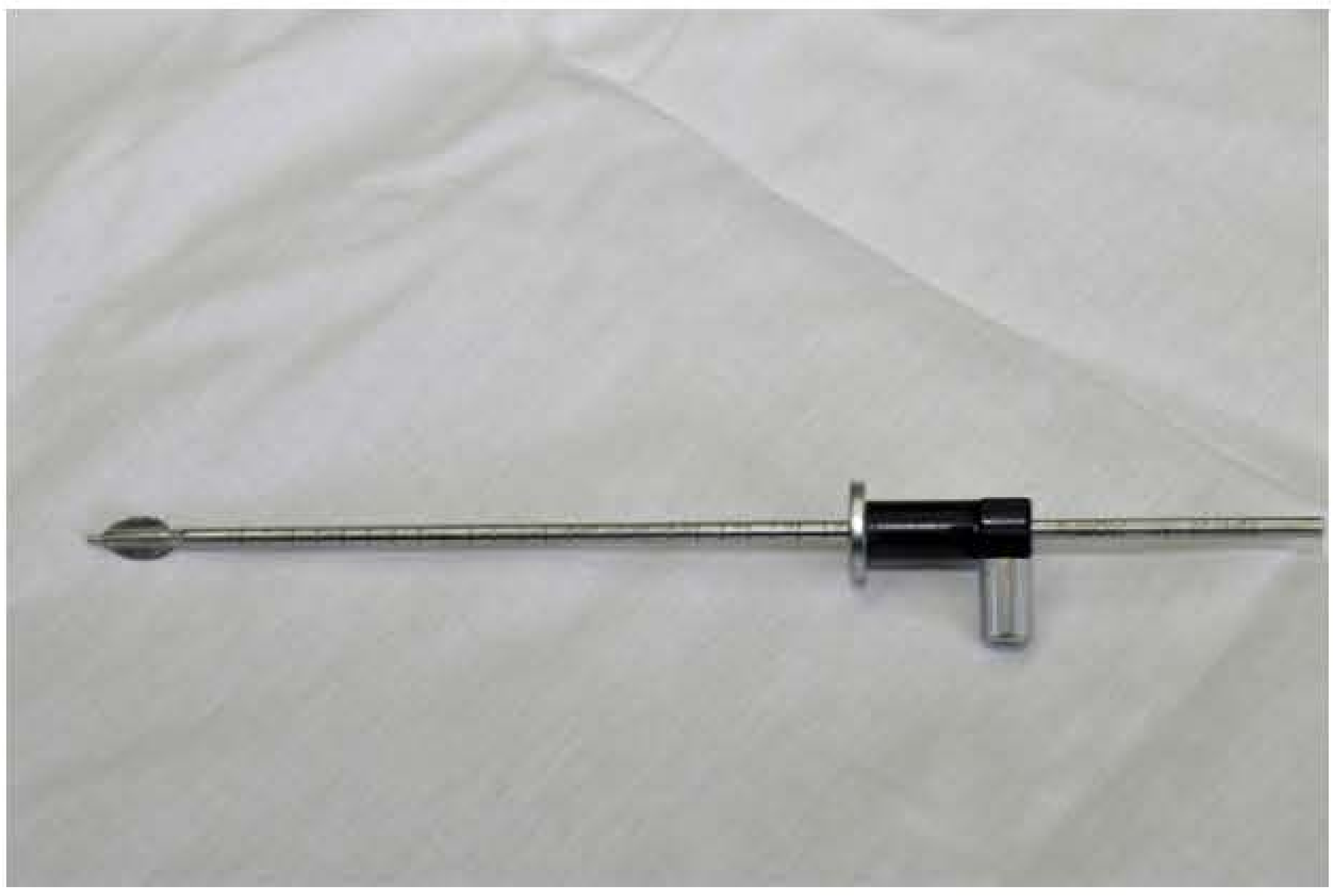

FIGURE 2.19 **Lombotome for percutaneous interventions.**

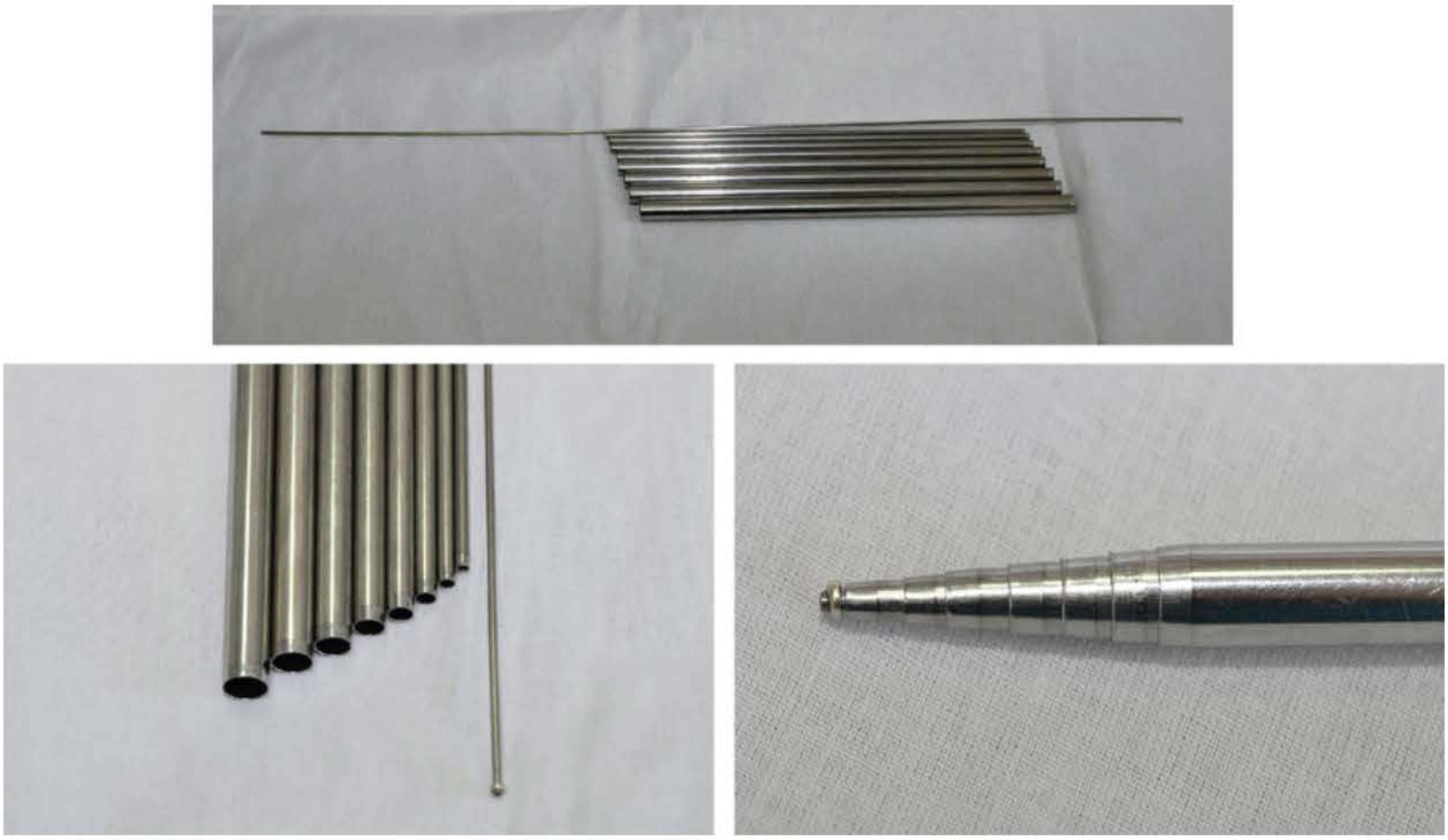

FIGURE 2.20 **Set of Alken metallic dilators.**

2.3.2.3 *Alken Coaxial Dilators*

Alken coaxial dilators are metallic cylinders with a progressively increasing caliber, every 2 F, which are mounted coaxially on a longer central rod and equipped with a distal olive (Fig. 2.20). The distal end of each cylinder has a particular shape to connect with the others and with the central rod's olive. Thus, none of the outer sheaths can surpass the inner one.

2.3.2.4 *Amplatz Dilators*

The Amplatz dilators (Cook Medical, Bloomington, IN, USA) are conical pieces made of plastic material, with a length of 30 cm and with maximal diameters varying between 12 F and 36 F (Fig. 2.21). They have a central channel and are loaded on the metallic rod with an olive, described in the section dedicated to the Alken dilators. The Amplatz sheath slides directly over this accessory.

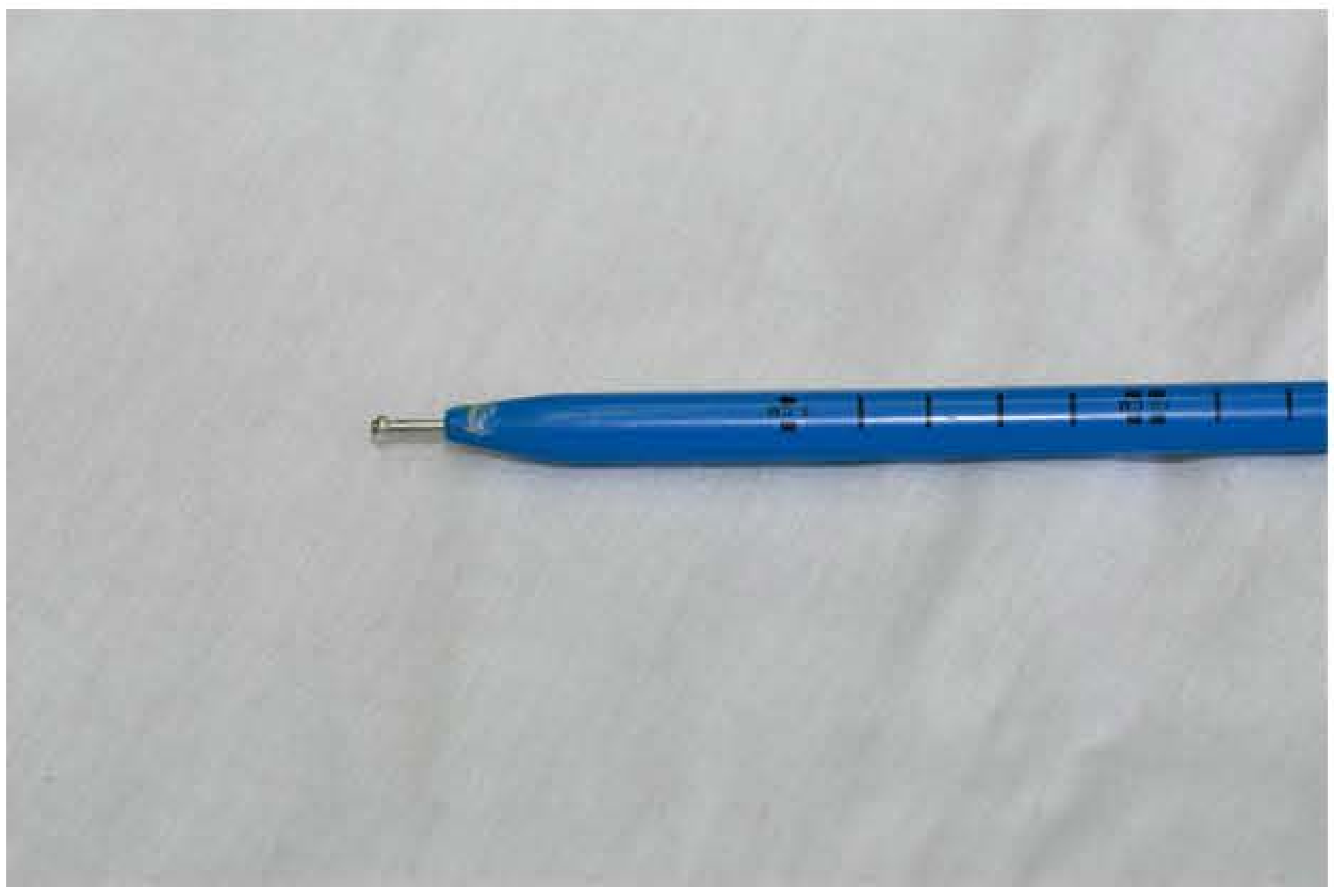

FIGURE 2.21 **Amplatz dilator.**

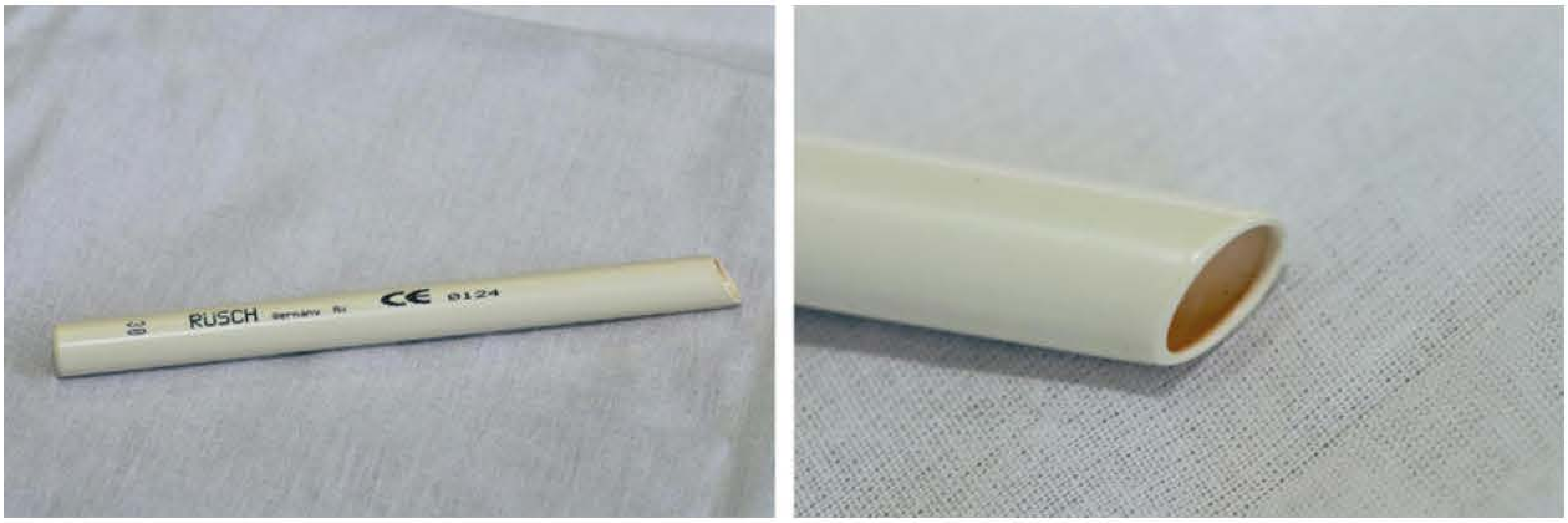

FIGURE 2.22 **Amplatz sheath.**

2.3.2.5 Balloon Dilators

Balloon devices are instruments for percutaneous tract dilation derived from those used in angiographic interventions. They have a central channel which slides on the guidewire and they are equipped with balloons with a length of up to 15 cm and a diameter of 10–12 mm when they are inflated. The handle has a manometer used to control the pressure during the tract's dilation, the maneuver being performed at high values of 15–30 atm.

The advantage of these instruments is represented by a lower potential aggressiveness against tissues. During balloon dilation, the angular and axial compression forces of the other dilators are replaced by lateral forces, theoretically associating a lower risk of tissue lesions and bleeding (Clayman et al., 1983).

The method's disadvantages are represented by the high costs of the instrument, but also by the difficulties to ensure a satisfactory dilation in the case of dense fascial connective tissues or of cicatricial tissues. In these situations, balloon dilation must be completed with another type of dilator.

2.3.3 Instruments for Maintaining the Percutaneous Tract

2.3.3.1 Amplatz Sheath

This is a plastic or Teflon cylinder, with oblique edges and variable diameters (Fig. 2.22), which is placed by sliding on the outside of the dilation devices.

The role of these sheaths is to maintain the percutaneous tract during the intervention, allowing an easy reaccess. They also prevent leakage, they allow evacuation of the excess irrigation fluid and of the lithiasic fragments alongside the nephroscope, they compress the blood vessels bleeding into the tract, and they prevent the migration of stones into the perinephric fat (Miller et al., 1984).

The sheaths can be radiopaque or radiotransparent with a radiopaque wire. The latter has the advantage of not masking the radiopaque lithiasic fragments during the intervention. The oblique end allows the stone fragments hidden under its distal end to be exposed by rotating the sheath.

2.4 LITHOTRIPSY DEVICES

Choosing the type of lithotripsy during PCNL depends on numerous factors including the dimensions and chemical composition of the stones, the type of nephroscopes used, and the existing technical equipment. The lithotripsy devices most frequently used during rigid PCNL are represented by the ultrasonic or pneumatic ones. Electrohydraulic lithotripsy is an efficient option even in the case of hard stones, having the advantage that it can also be used during flexible nephroscopy. However, due to the high potential of damaging the adjacent tissues, it should only be used in well-selected cases.

The introduction of flexible nephroscopes into clinical practice has increased the applicability of Ho:YAG laser in nephroscopy. It can be used for the fragmentation of stones in areas of the pyelocaliceal system that are accessible only by flexible approach.

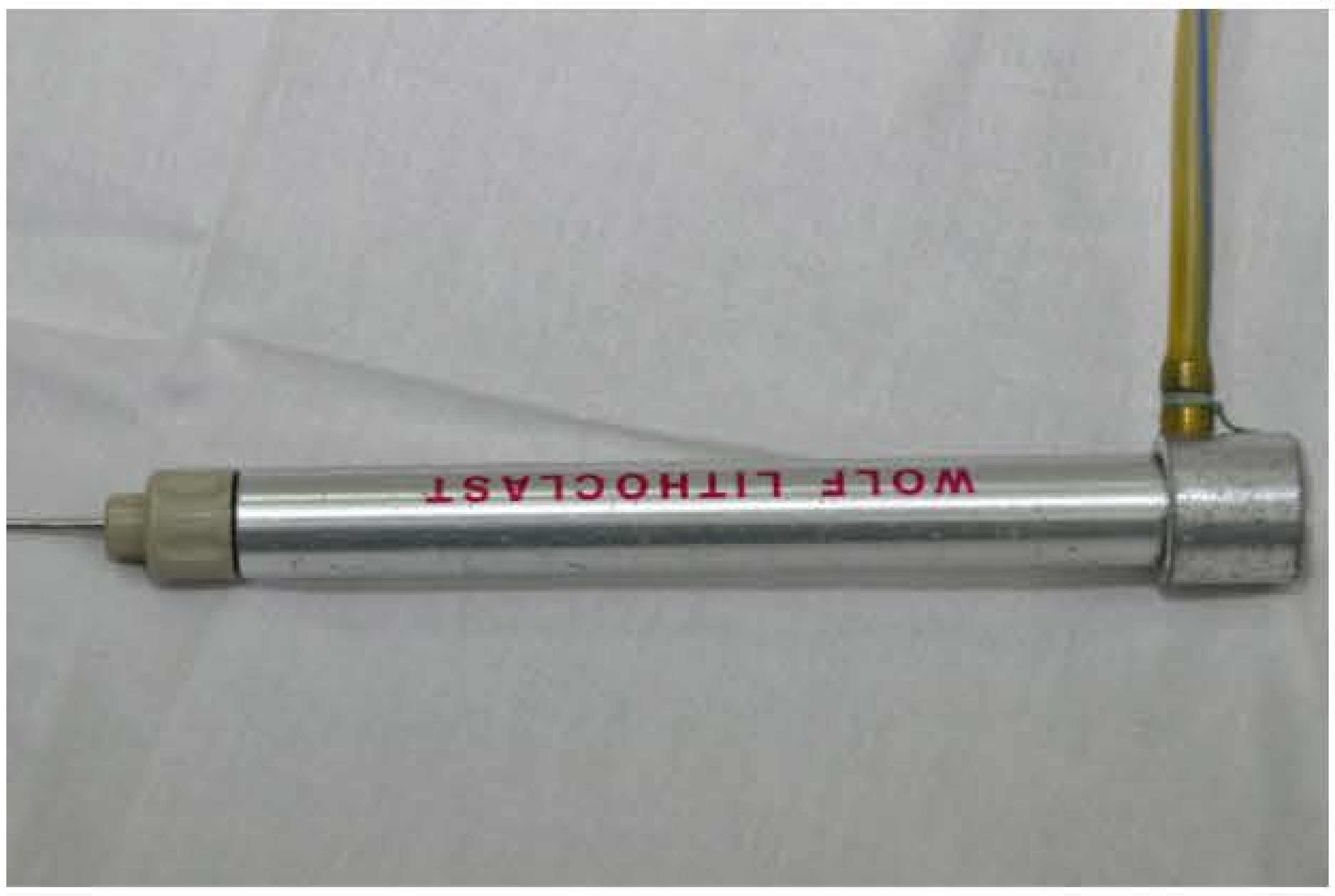

FIGURE 2.23 **The handle of a pneumatic lithotripter.**

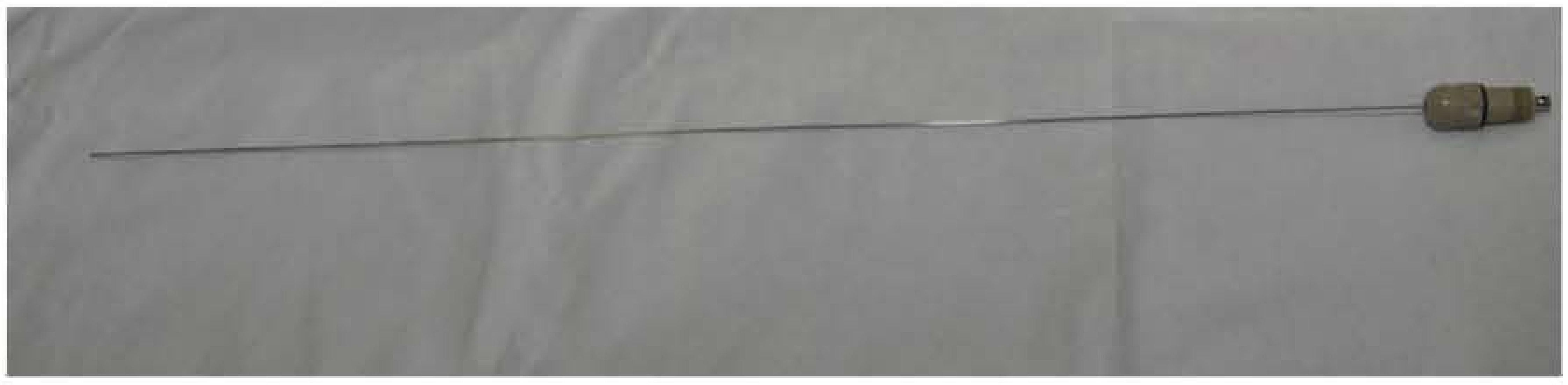

FIGURE 2.24 **The probe of the pneumatic lithotripter.**

In consequence, the European Association of Urology guidelines recommend the use of ultrasonic, ballistic, or Ho:YAG lithotripters in the case of rigid nephroscopy (grade A recommendation), while the Ho:YAG laser is the option of choice for flexible percutaneous approach (Türk et al., 2012).

2.4.1 Ballistic/Pneumatic Lithotripsy

The principle of this type of lithotripter consists of the direct contact between the end of a rigid probe and the stone, the energy provided by a compressor being transmitted through compressed air to a projectile located in the instrument's handle (Fig. 2.23). This is propelled to the end of the metallic probe with a pressure of 3 atm and a frequency of 12 Hz. The first such lithotripter was the Swiss Lithoclast (EMS, Nyon, Switzerland). Its probes have a diameter varying between 0.8 mm and 3 mm.

Lithotripsy is performed by placing the probe (Fig. 2.24) in contact with the stone's surface (Fig. 2.25) under direct visual control. Triggering the generator causes repetitive impacts of the probe's tip against the stone determining its fragmentation through a mechanism similar to the functioning of a pickhammer. The fragmentation's efficiency is increased by pushing the stone against the urothelium.

This working mechanism raised the problem of the risk of injuring the urothelium's surface during the procedure (Lasser and Pareek, 2012). Studies performed on animals showed that the direct contact of the probe with the urinary tract's wall does not determine its perforation (Santa-Cruz et al., 1998). Histological studies have demonstrated the occurrence only of superficial abrasions and of edema in the profound layers (Piergiovanni et al., 1994).

Another advantage of ballistic fragmentation lies in the fact that heat is not generated during the procedure (Lasser and Pareek, 2012).

A disadvantage of using this type of lithotripsy derives from the fact that the probes are rigid and cannot be used on flexible nephroscopes. In an attempt to overcome this shortcoming, nitinol lithotripsy probes were produced (Tawfiek et al., 1997) to allow their use on flexible instruments, but they have the disadvantage of significantly reducing deflection and the efficiency of fragmentation (Zhu et al., 2000). Also, they do not allow the simultaneous evacuation of resulting fragments.

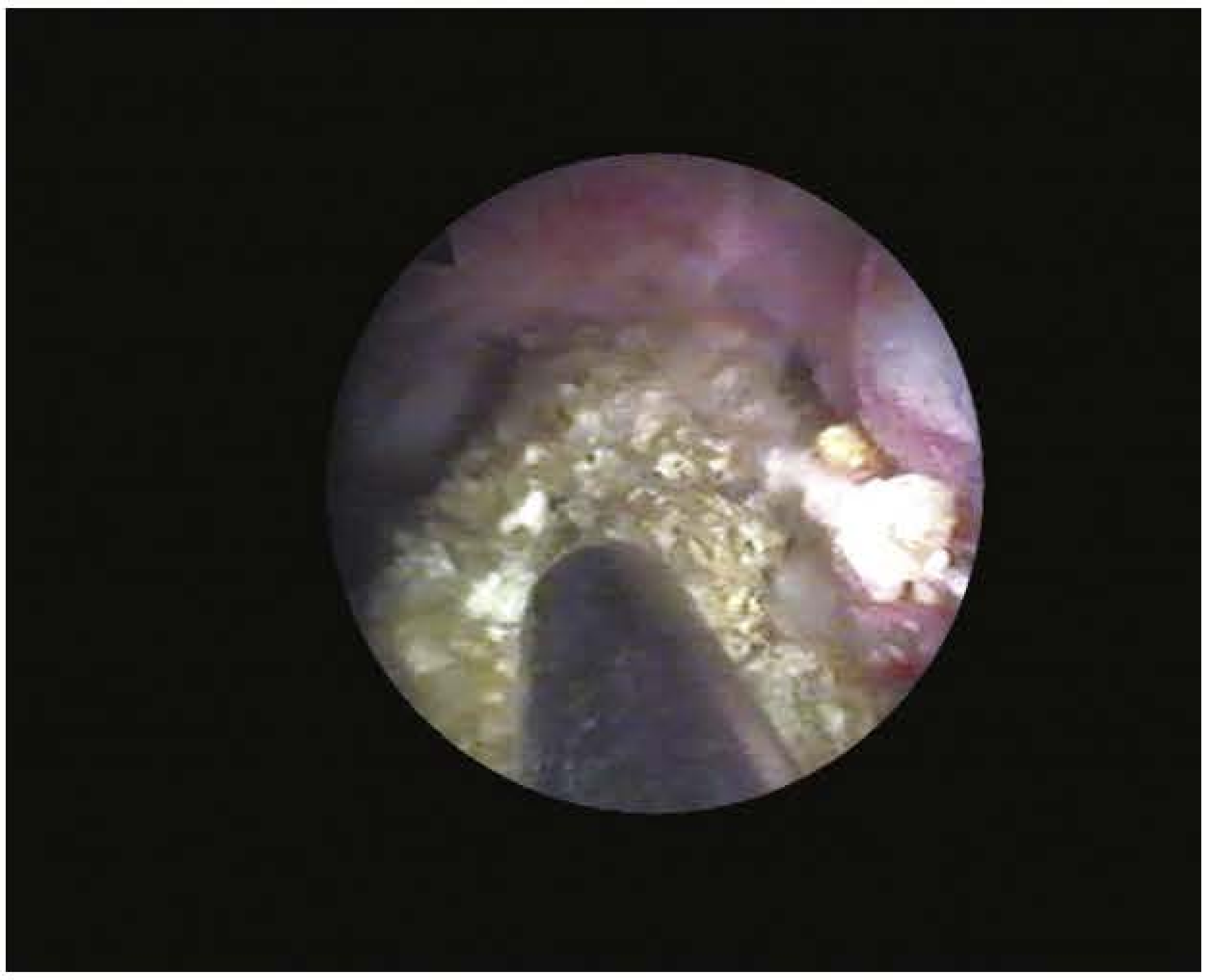

FIGURE 2.25 **Ballistic lithotripsy of a pyelic stone.**

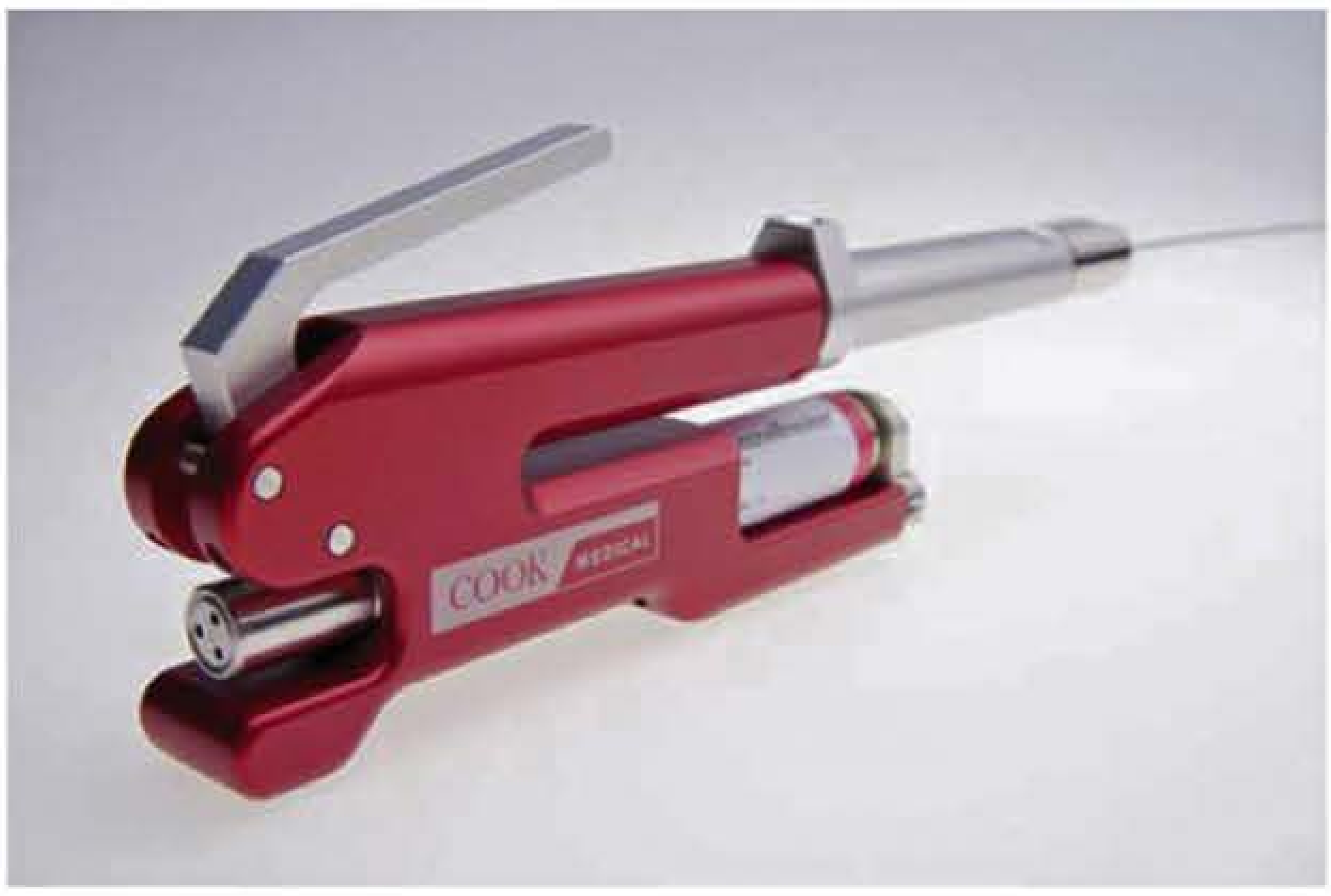

FIGURE 2.26 **Cook LMA Stonebreaker lithotripter.**

Therefore, to allow the extraction of fragments but also to reduce the risk of retropulsion and increase the contact time during fragmentation, an aspiration instrument was developed, the Lithovac. This was first used in practice by Haupt et al. (1995). Subsequent reports (Delvecchio et al., 2000) showed an increased efficiency of lithotripsy, maintaining a clear endoscopic field. It allows the evacuation of fragments smaller than 2 mm. However, its use was limited by the frequent obstruction of the Lithovac.

A particular type of pneumatic lithotripter is represented by the Cook LMA Stonebreaker (Fig. 2.26). This is a lightweight portable device. Its clinical evaluation in a multi-institutional study (Rané et al., 2007) showed a 100% success rate in stone fragmentation.

Globally, ballistic lithotripsy was found to be a safe and efficient alternative which ensures an easy fragmentation of stones. Its limitations are due to the high risk of retropulsion, the need for manual extraction of the fragments, and the impossibility of using it on flexible endoscopes.

2.4.2 Ultrasonic Lithotripsy

Ultrasonic lithotripsy is based on the use of waves with an acoustic frequency higher than that of the human audio spectrum (20 kHz). The principle of the generation of these waves consists of using piezoelectric crystals which, under the action of electric current, generate ultrasounds with a frequency between 23 kHz and 25 kHz which are transmitted along the probe (Fig. 2.27). At its end, the ultrasounds are converted into vibrations. As a result, lithotripsy is performed through mechanical energy, the direct contact between the probe's end and the stone being necessary. The

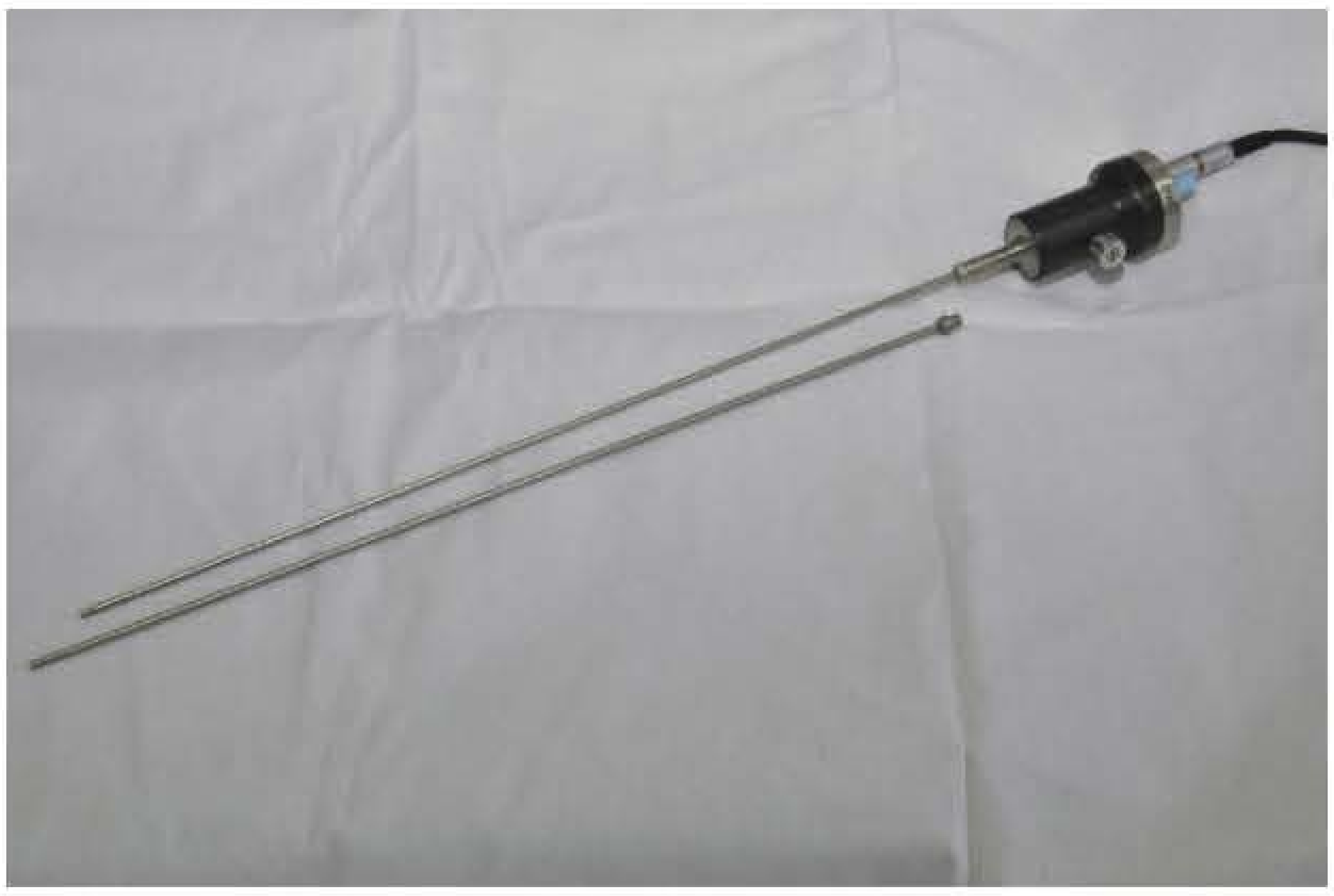

FIGURE 2.27 **The handle and probes of the ultrasonic lithotripter.**

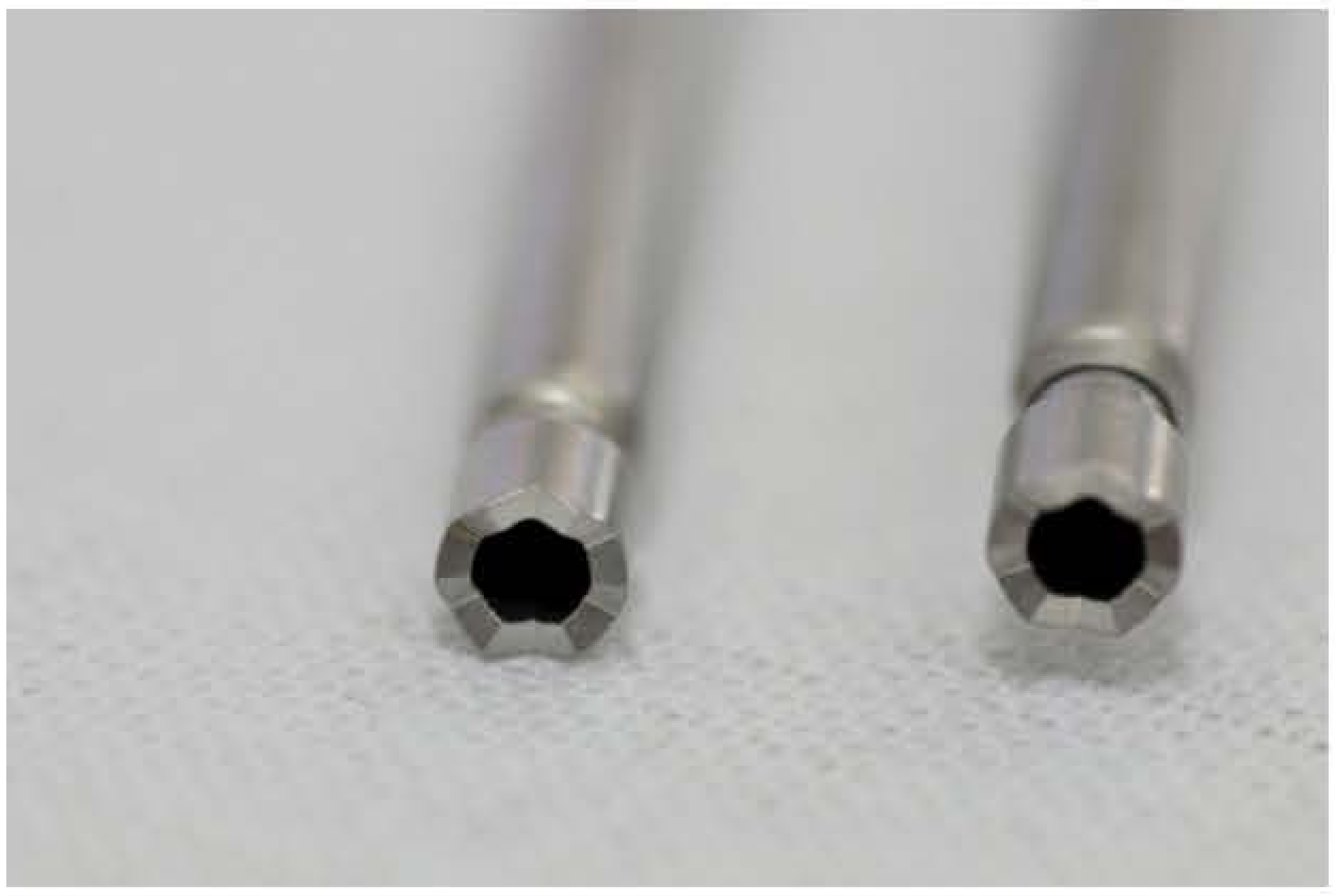

FIGURE 2.28 **Ultrasonic probe with a central aspiration channel.**

dimensions of the probes vary between 2.5 F and 6 F. The higher-caliber probes present in their axis a lumen which allows aspiration simultaneously with the extraction of the resulting fragments (Fig. 2.28).

Its use requires continuous irrigation. If irrigation is interrupted during lithotripsy, overheating of the instruments can occur, affecting their functioning (Lasser and Pareek, 2012). Also, damage to the adjacent tissues can occur. The temperature changes at the level of the probe's tip are minimal at an irrigation flow of 30 mL/min (Marberger, 1983).

Regarding the potential mucosal lesions as a result of the direct contact between the probe's tip and the urothelium, as in the case of pneumatic lithotripsy, the studies conducted (Piergiovanni et al., 1994) have shown that there is no risk of perforation, but only of superficial abrasions and of edema in the profound layers.

As in the case of ballistic lithotripsy, fragmentation's efficiency can be increased by fixing the stone to the wall of the renal cavities (Lasser and Pareek, 2012).

The first such lithotripter was represented by the Aachen model developed by Karl Storz Endoscopy (Tuttlingen, Germany). All models developed subsequently are based on the principles of the Aachen model.

Different types of ultrasonic lithotripters have been developed (Storz 27085K, Wolf 2167.01, Circon USL 2000). An *in vitro* comparison (Haupt and Haupt, 2003) regarding their efficiency demonstrated that the EMS prototype had a higher efficiency than the others, followed by the Circon lithotripter.

Due to the increased dimensions of the probes and the possibility of aspirating the resulting fragments, ultrasonic lithotripsy represents a first-line choice in rigid PCNL.

To achieve fragmentation in optimal conditions, it is preferred to trigger the probe over short periods of time, thus avoiding the risk of overheating and of potential secondary thermal lesions.

2.4.3 Combined Pneumatic and Ultrasonic Lithotripsy

Recent evaluations have demonstrated that the most efficient intracorporeal lithotripsy devices are those that combine ultrasonic and pneumatic lithotripsy, which were first tested in 2001 (Haupt et al., 2001). The first such instrument was the Lithoclast Master (EMS, Nyon, Switzerland) [in the United States, the Lithoclast Ultra (Boston Scientific, Natick, MA)] (Fig. 2.29).

The central unit allows the simultaneous or separate use of the two types of lithotripsy (Lasser and Pareek, 2012). The pneumatic probe is placed through the channel of the ultrasonic one, still allowing aspiration through its lumen. The pneumatic probe must be placed exactly at the opening of the ultrasonic probe's lumen so that both probes are in contact with the stone. The frequency for the pneumatic component can be adjusted between 2 Hz and 12 Hz, while for the ultrasonic component it can be adjusted between 24 Hz and 26 Hz.

Choosing one of these two types of fragmentation or their simultaneous triggering is based on the characteristics of the stone. Pneumatic lithotripsy is more efficient for the initial fragmentation of the bulky and rough stones, while the ultrasonic component can be used for the destruction and evacuation of smaller and softer fragments.

In vivo (Haupt et al., 2001) and *in vitro* (Hofmann et al., 2002; Auge et al., 2002) evaluations demonstrated increased efficiency regardless of the type of lithiasis, as well as a significant reduction in the time required for fragmentation.

A new handle was developed in order to solve the problem of the aspiration channel's obstruction, the "Vario ultrasound handpiece." It allows a variation of the ultrasound frequency between 23.2 kHz and 26.4 kHz, ensuring

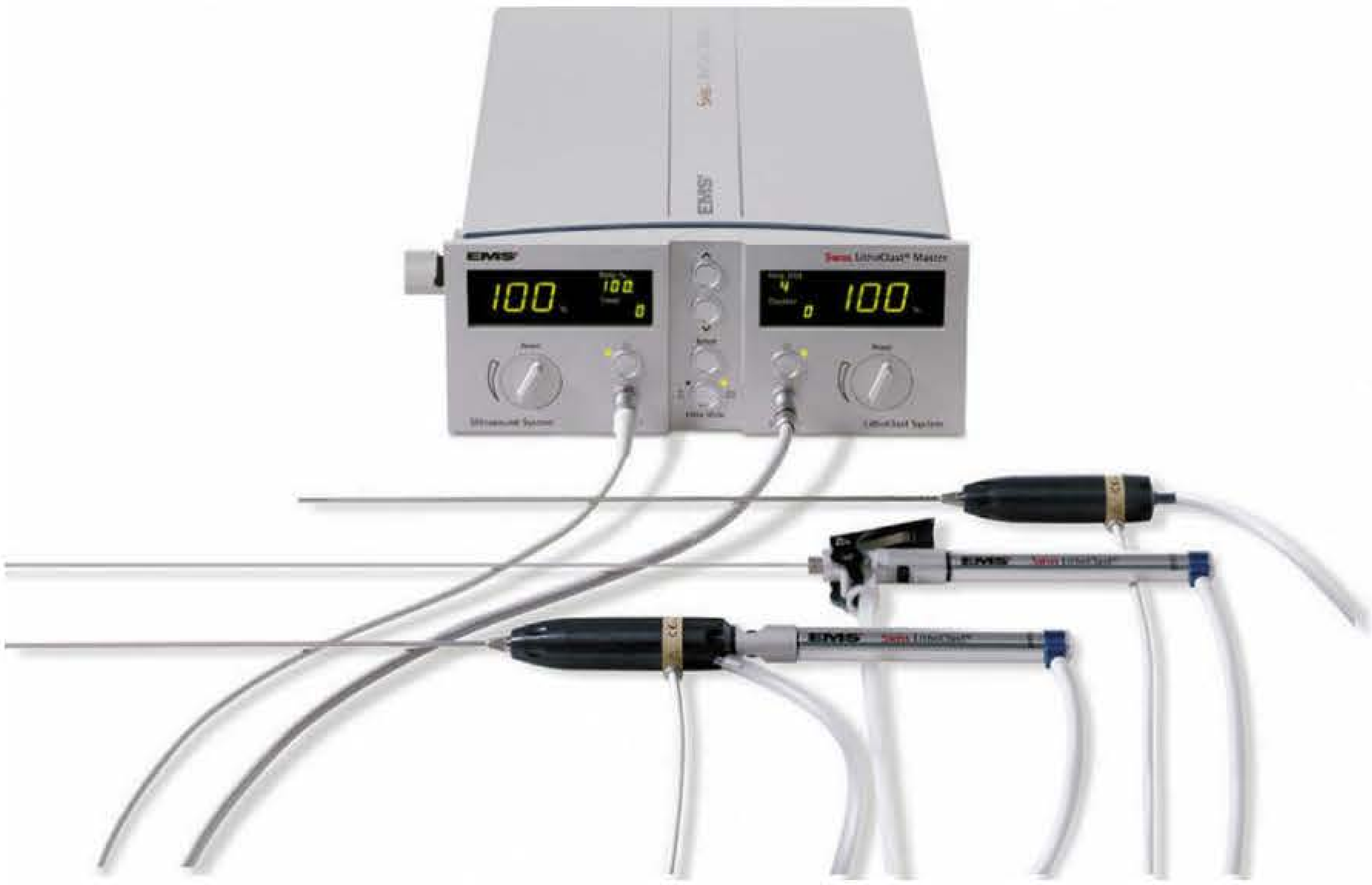

FIGURE 2.29 **Lithoclast Swiss Master.**

a greater power with a more reduced heating of the probe, increasing its lifespan. The handle's configuration also reduces the risk of the aspiration channel's obstruction.

The use of standard aspiration provided by the ultrasonic device frequently causes its pressure to be higher than the irrigation pressure, leading to penetration of air into the renal cavities, impairing visibility. The Swiss LithoPUMP (EMS, Nyon, Switzerland) was developed to overcome this shortcoming. In association with the Lithoclast Master it allows aspiration to be adapted according to the procedure. Aspiration is activated only while the ultrasonic component is functioning. Therefore, a better visualization as well as the prevention of the ultrasonic lithotripsy probe's overheating are obtained by using this device.

2.4.4 Electrohydraulic Lithotripsy

Initially described by Yutkin in 1950, electrohydraulic lithotripsy was the first method of intracorporeal lithotripsy used in practice (Buchholz, 2002). Electrohydraulic lithotripsy probes (Fig. 2.30) are made of two concentric electrodes with voltages of different polarities.

The stone fragmentation mechanism is determined by an electrical discharge in a liquid medium. This evaporates the water around the probe, causing the emergence of a cavitation bubble that expands rapidly, followed by

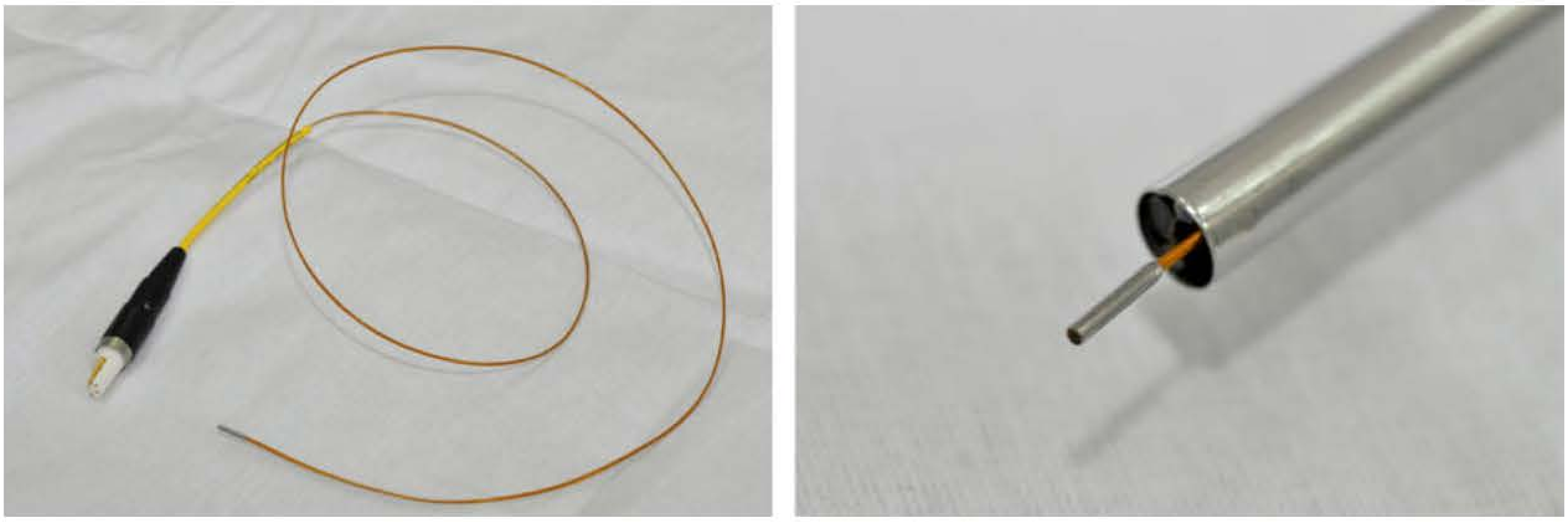

FIGURE 2.30 **Electrohydraulic lithotripsy probe.**

its collapse. The result is the generation of a shockwave that produces fragmentation of the stones (Knudsen and Denstedt, 2006). This lithotripter's probes have dimensions varying between 1.9 F and 9 F. Although it was initially recommended to use a 1:6 saline solution as irrigation fluid, it was subsequently found that isotonic or hypotonic solutions can be used (Denstedt and Clayman, 1990).

The use of electrohydraulic lithotripsy has a series of advantages regarding the reduced costs compared to the other lithotripters, although the probes are for single use, being a widely accessible method (Lasser and Pareek, 2012).

The disadvantages that limit this method's performances derive primarily from a greater aggressiveness against the surrounding tissue and the optical systems of the endoscopes. Thus, due to the risk of deteriorating the optical system, the electrohydraulic lithotripsy probe should be discharged at least 2–5 mm from the flexible nephroscope's tip (Lingeman et al., 2002). *In vitro* evaluations have demonstrated a greater potential for thermal lesions of the urothelium (Piergiovanni et al., 1994). The perforation rate described in the literature varies between 2.9% (Başar et al., 1997) and 17.6% (Hofbauer et al., 1995).

Another disadvantage is the possibility of the probes' deterioration during their use, requiring the extraction of the detached fragments (parts of the external insulating layer, distal metallic ends).

In the case of using this method during PCNL, Clayman (1984) reported a lower efficiency compared with ultrasonic or pneumatic lithotripsy; nevertheless, electrohydraulic lithotripsy maintains its indications for stone fragmentation with flexible nephroscopes in situations where Ho:YAG laser lithotripsy is not available.

2.4.5 Laser Lithotripsy

The first laser was developed by Maiman in 1960; its first use in urology was reported by Parsons et al. (1966).

Technical progresses have brought the Ho:YAG laser to the forefront among the modalities of stone fragmentation (Fig. 2.31). This has a 2100-nm wavelength, and the diameter of the fibers ranges from 200 μm to 1000 μm.

In the case of flexible PCNL, the Ho:YAG laser has become the elective intracorporeal lithotripter (Gupta, 2007), being the most efficient lithotripsy method for all types of stones, regardless of their location. It is rapidly absorbed by water (3 mm) and has a low tissular penetrability (0.4 mm) (Lasser and Pareek, 2012). These characteristics lower the risk of thermal lesions, ensuring a superior safety. Direct contact between the tip of the probe and the stone is necessary to achieve the lithotripsy.

At the moment, this is considered to be the most efficient source of energy for intracorporeal lithotripsy. Other advantages of using the Ho:YAG laser lithotripsy include a greater efficiency than electrohydraulic lithotripsy, fragmenting even cystine stones. Additionally, the stones are destructed into very small fragments which are evacuated with the irrigation fluid, without requiring the use of accessory extraction instruments.

The risk of perforating the urinary tract during lithotripsy is very low, but is higher compared to pneumatic or ultrasonic lithotripsy (Lasser and Pareek, 2012). An *in vitro* study demonstrated the absence of urothelium perforations when the probe's tip is placed 2 mm from the urothelium (Santa-Cruz et al., 1998). Maintaining the laser fiber at a distance of 1 mm from the urinary tract's mucosa ensures a very good safety profile. Furthermore, the absence of photoacoustic effects lowers the risk of bleeding, allowing its use in anticoagulated patients (Kuo et al., 1998).

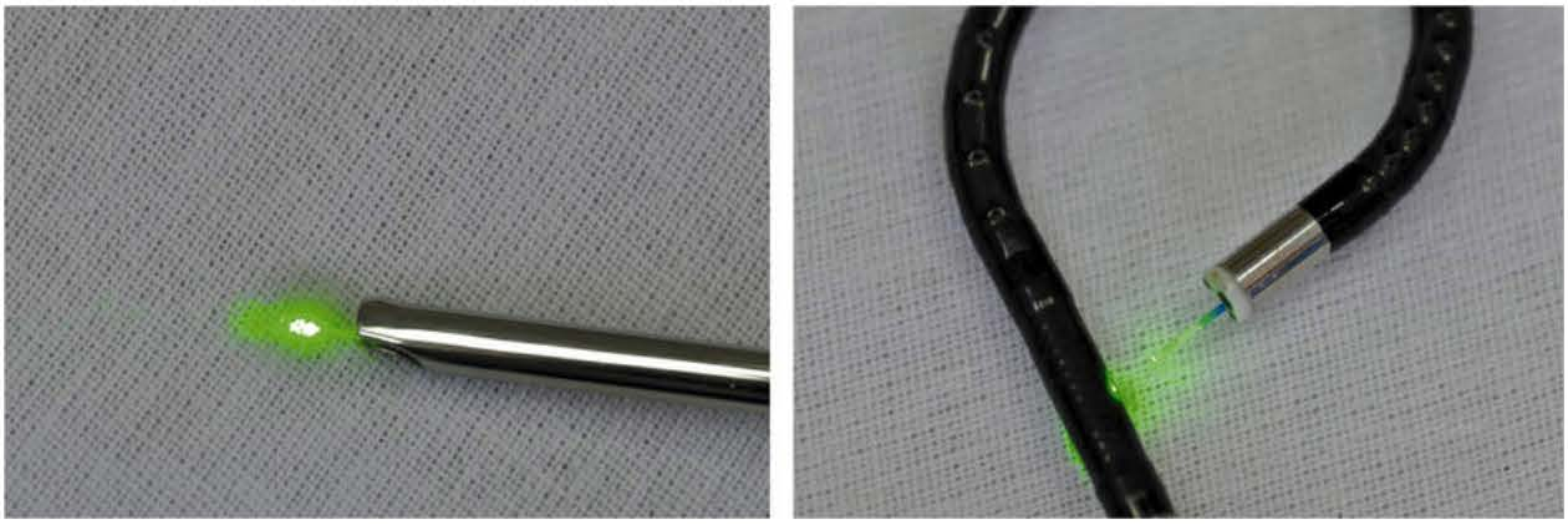

FIGURE 2.31 **Ho:YAG laser probe.**

During fragmentation the probe's tip must be maintained at least 2 mm from the nephroscope's end to avoid damaging the optical system.

The use of the Ho:YAG laser has the disadvantage of high costs, both in terms of the device itself but also of the fibers, even if they are reusable. Because of the photothermal effect, various chemical reactions occur during lithotripsy according to the stone's chemical composition. Thus, during lithotripsy of uric acid stones, the production of cyanides has been demonstrated, but in a low amount, without clinical significance (Corbin et al., 2000).

The 70-W high-power Ho:YAG laser has been shown to have an increased efficiency in stone fragmentation, significantly reducing the procedure's duration. The results (Sun et al., 2009) demonstrated that this method is safe and efficient in patients with large stones.

Another type of laser is the erbium:YAG (Er:YAG), which acts through a photothermal effect similar to that of the Ho:YAG laser. The Er:YAG has a wavelength of 2940 nm, more efficiently absorbed by the urinary stones than the 2140-nm wavelength of the Ho:YAG (Teichman et al., 2001). Experimental studies are still currently under way to develop fibers for this type of laser, to be used during endoscopic surgery.

Also, the FREDDY (Frequency-Doubled Double-Pulse Nd:YAG) laser, a modified variant of the Nd:YAG, has been proposed for lithotripsy to emit at 523 nm (half of its wavelength) (Teichman, 2007). The advantages of this type of laser are the low cost and, due to the wavelength at which it functions, the minimal risk of tissue lesions. The laser works with silicone fibers that are very elastic, a property that makes them ideal for use on flexible endoscopes (Delvecchio et al., 2003). The efficiency of FREDDY lithotripsy is lower for stones with certain chemical compositions (cystine, calcium oxalate monohydrate).

2.5 EXTRACTION INSTRUMENTS

There is currently a very wide array of accessory extraction instruments.

They can be flexible (usually of a lower caliber and implicitly more fragile) or rigid (thicker and more robust). The flexible ones can be used on flexible as well as rigid nephroscopes and are represented by basket probes, forceps, etc., similar to those described in the section dedicated to ureteroscopy. The wider working channel of the flexible nephroscope allows insertion of larger caliber instruments than in the retrograde approach, more efficient for the extraction of stones and also more durable.

The main categories of rigid extractors are represented by alligator forceps, tripod (or tetrapod) graspers, and smooth graspers. The alligator forceps allow a good grip on the lithiasic fragments because of the jaws' profile. However, due to the scissors-like mode of opening, they require the presence of a space around the stones, and the actioning mechanism is relatively fragile if an increased pressure is applied on it. The force developed by the jaws is significant, with the possibility of uncontrolled fragmentation of stones with a reduced consistency. For these types of stones, alligator graspers with curved jaws that delimit a small space between them can be used (Miller et al., 1984).

Tripod graspers (Fig. 2.32) have three solid arms, with curved ends in the shape of claws. They are one of the most efficient extracting instruments (Miller et al., 1984), with a good grasp on the fragments while requiring only a reduced space for opening.

However, the thin and rough ends of the arms can easily perforate the pyelocaliceal system's wall. There are also four-arm graspers, considered to be less efficient. There are also tripods with an optical system (Wickham-Miller nephroscope, Karl Storz GmbH), designed so that the arms open only under direct visual control, in the endoscopic

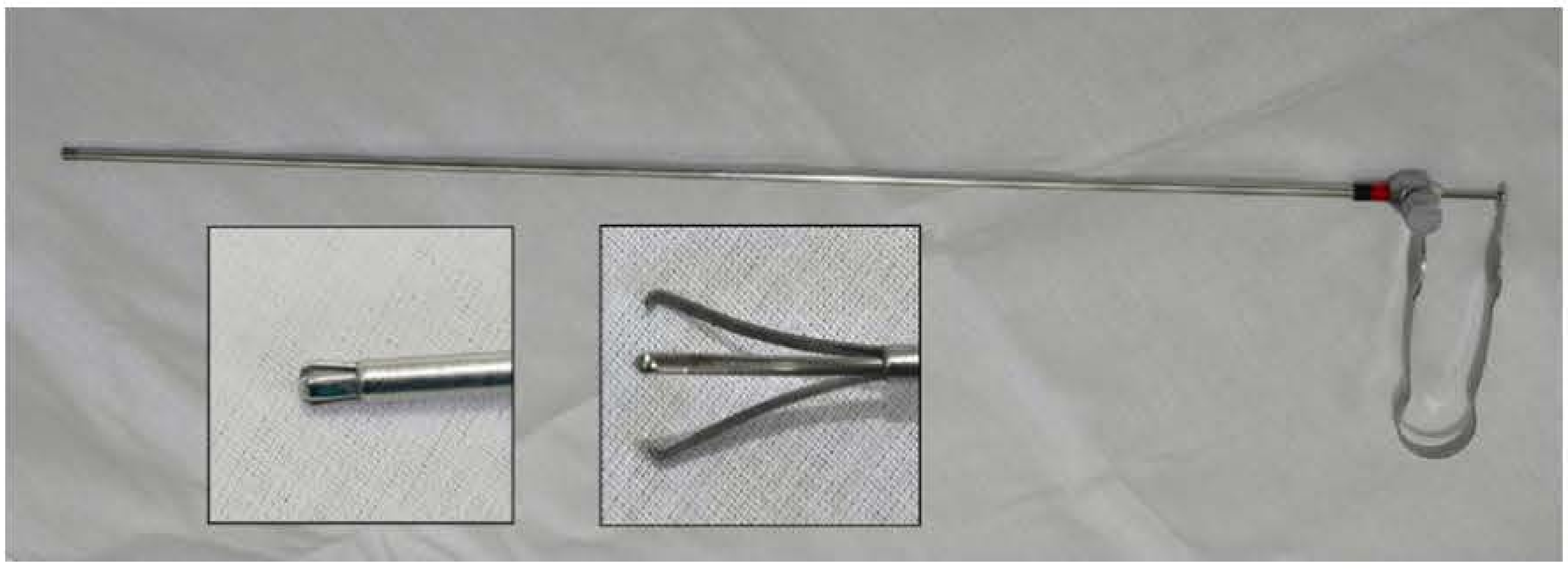

FIGURE 2.32 **Tripod grasper.**

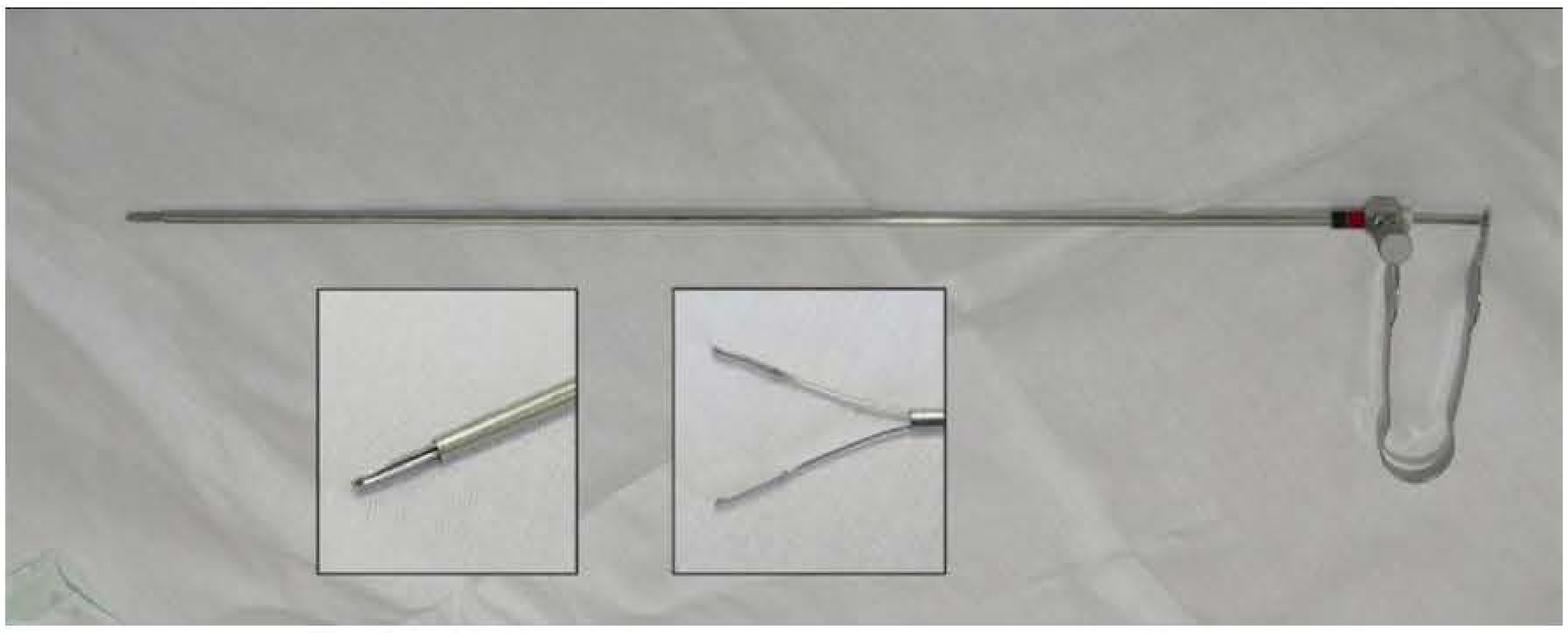

FIGURE 2.33 **Grasper with smooth jaws.**

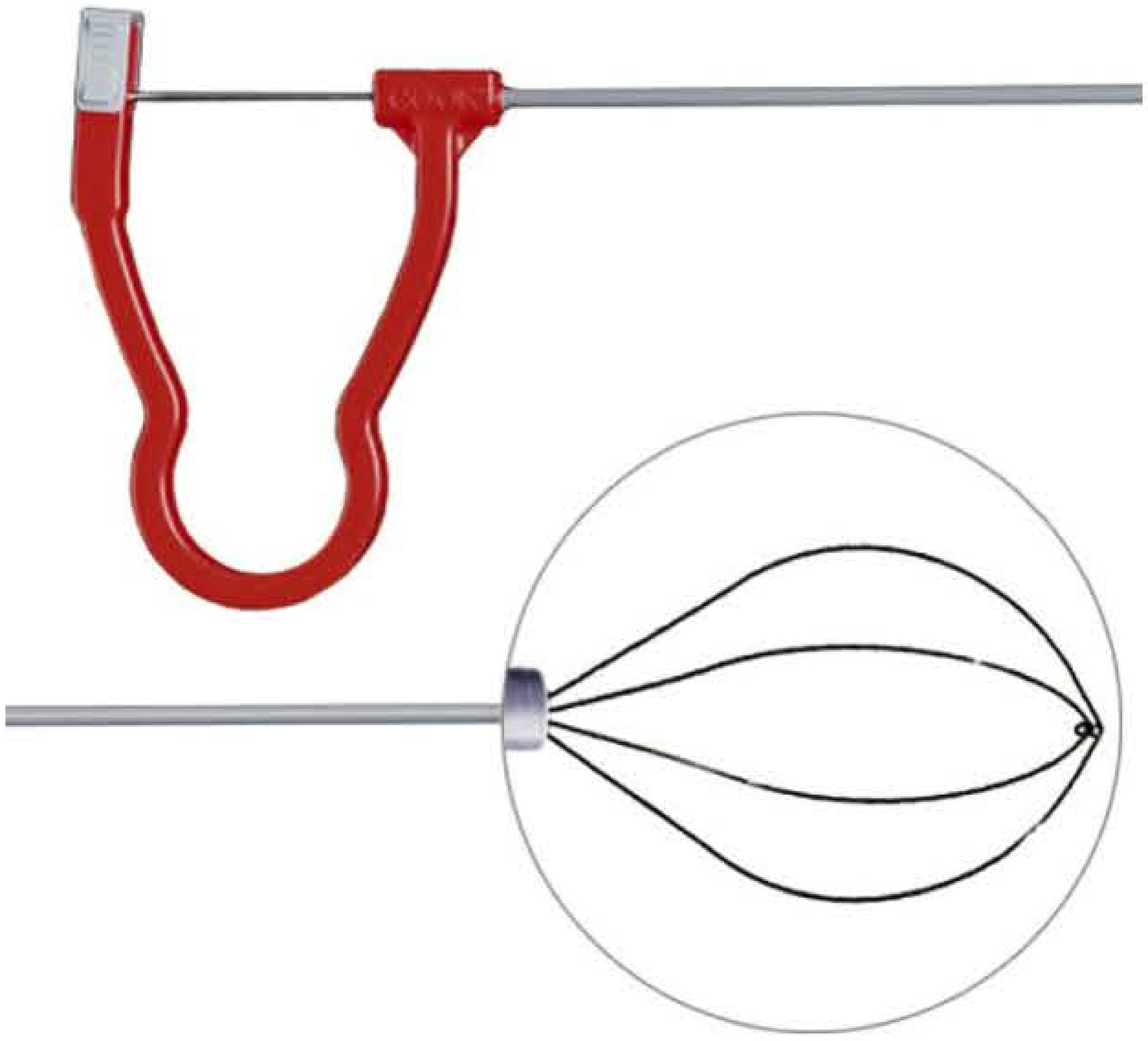

FIGURE 2.34 **Perc NCircle extractor for percutaneous interventions (Cook Medical, Bloomington, IN, USA).**

field, thus avoiding damaging the wall by eccentrically pushing the instrument inserted through the working channel.

Smooth graspers (Fig. 2.33) do not achieve a very good grip.

Also, their complete opening implies that they extend out from the working channel and from the exterior sheath of the extractor, a reason for which it must be done with caution so as not to damage the tissues. Closing the jaws, as in the case of the tripod, implies their withdrawal, and the movement must be combined with one of anteriorly pushing the instrument so that the stone is caught.

Development of new instruments is a continuous process. Thus, the Perc NCircle® hybrid (Cook Medical, Bloomington, IN, USA) (Fig. 2.34) combines the distal part of a basket probe with the actioning mechanism of a grasper.

2.6 NEPHROSTOMY TUBES

Nephrostomy tubes can be placed at the end of the intervention. This is considered the standard procedure, since "tubeless" percutaneous interventions have not imposed themselves in current clinical practice, at least for the moment.

Tubes with a permeable or impermeable distal end are commonly used, with perforations only in this region so that urine does not leak through the tract. The tube's external diameter must be equal with the diameter of the tract to compress the blood vessels that bleed at this level. These tubes are fixed by suturing them to the skin.

Foley catheters can also be used, with the balloon inflated in the renal pelvis.

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CHAPTER

3

Percutaneous Approach in Renal Lithiasis

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3.1 INDICATIONS

After Goodwin's first description (Goodwin et al., 1955) of a percutaneous renal intervention in a patient placed in the prone position, Fernstrom and Johansson (1976) reported the first percutaneous nephrolithotomy in 1976.

After several years, Alken et al. (1981) published a first series of percutaneous interventions for removing renal stones using a lithotripter with ultrasounds, initially designed to fragment vesical lithiasis, but used now to disintegrate renal stones.

Since the first description of percutaneous nephrolithotomy (PCNL), the indications for percutaneous approach have suffered significant changes as a result of increased experience, technological evolution, economical factors, and patient preferences.

Although the use of less invasive methods, especially of extracorporeal lithotripsy, but also of retrograde flexible ureteroscopic approach, has limited the indications for percutaneous surgery for this condition, PCNL has maintained its role in the first-line treatment of voluminous complex renal lithiasis, of lithiasis resistant to extracorporeal fragmentation, or of lithiasis occurring on malformed kidneys.

Many factors are involved in establishing the therapeutic indication for renal stones: number, size, composition (evaluated by Hounsfield units) and location of the stones, the presence of hydronephrosis, caliceal diverticula, pyeloureteral junction stenosis, or renal malformations.

In addition to the elements related to lithiasis characteristics, a number of general factors are also involved in establishing the therapeutic indication: the patient's profession, obesity, skeletal anomalies, comorbidities or previous interventions, the presence of urinary diversions, etc.

3.1.1 Indications for PCNL According to the Characteristics of the Lithiasis

The volume of the lithiasic mass is one of the most important factors in choosing the therapeutic option (Duvdevani et al., 2007), being closely correlated with the stone-free rate, the need for additional procedures, or the occurrence of complications.

According to the European Association of Urology guidelines, PCNL represents the first therapeutic alternative for pyelocaliceal stones larger than 2 cm (Fig. 3.1) (grade of recommendation B) (Türk et al., 2012). Although its efficacy is also affected by the dimensions of the stones, for extracorporeal lithotripsy and retrograde ureteroscopy the success rates are inversely proportional with the dimensions of the stones (Argyropoulos, 2010; Srisubat, 2009; Sahinkanat et al., 2008; Danuser, 2007). The data in the literature confirm the fact that the differences between the efficiency of percutaneous therapy and of the other minimally invasive methods increase with the size of the stones approached. Thus, SWL and intrarenal retrograde lithotripsy have a success rate of 63% (ranging between 39% and

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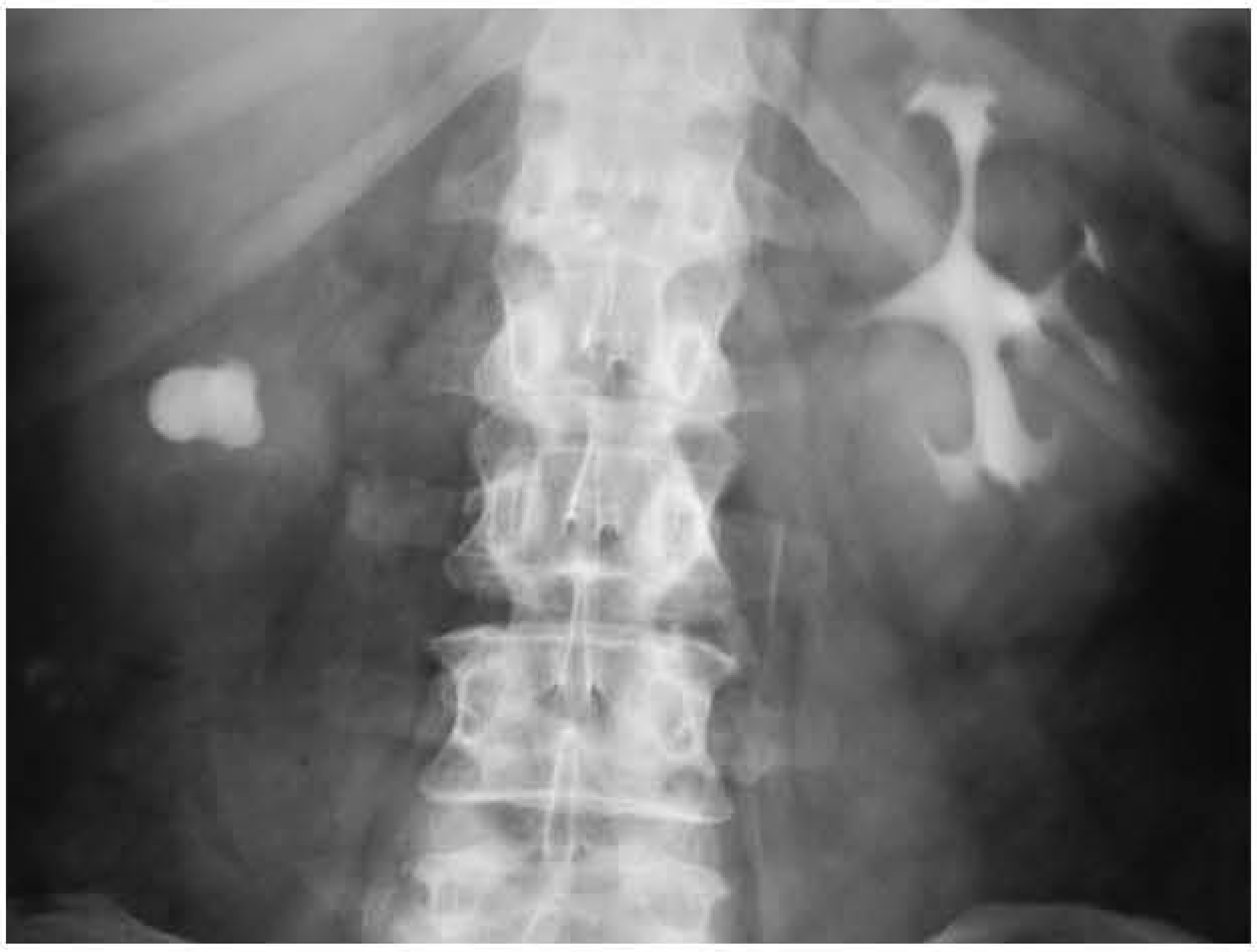


FIGURE 3.1 **Voluminous right renal lithiasis.**

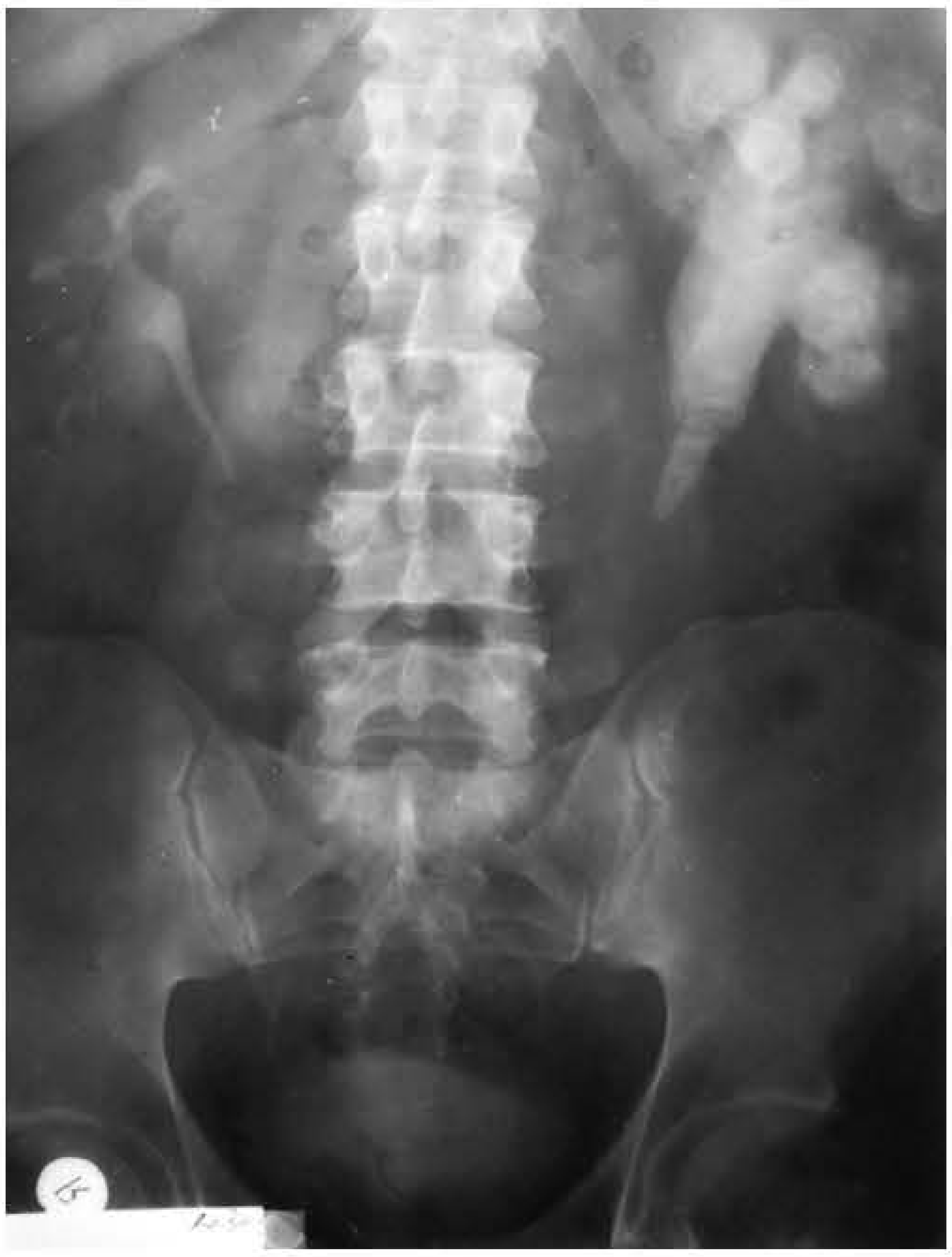


FIGURE 3.2 **Left staghorn stone (urographic aspect).**

70%) and, respectively, of 45–47% for stones larger than 2 cm (Grasso and Ficazzola, 1999; Robert et al., 1997; Méndez Probst et al., 2009).

Also, the use of extracorporeal lithotripsy in these patients implies multiple sessions, an increased risk of ureteral obstruction and steinstrasse syndrome, or additional procedures (Pearle, 2005).

Regarding staghorn calculi (Fig. 3.2), a meta-analysis performed by the Practice Guidelines Committee of the American Urology Association suggests that these complex cases can be approached percutaneously with a stone-free rate of 65% compared to 62, 36, and 42%, respectively, for open surgery, sandwich therapy, or extracorporeal lithotripsy (Preminger et al., 2005).

Excepting patients with very large and/or complex staghorn calculi (Fig. 3.3), PCNL is a therapeutic modality which is preferred to open surgical treatment due to its lower morbidity.

The only prospective, randomized study comparing PCNL to SWL for staghorn lithiasis (Fig. 3.4) demonstrated stone-free rates that were three times higher for percutaneous therapy compared to extracorporeal lithotripsy in

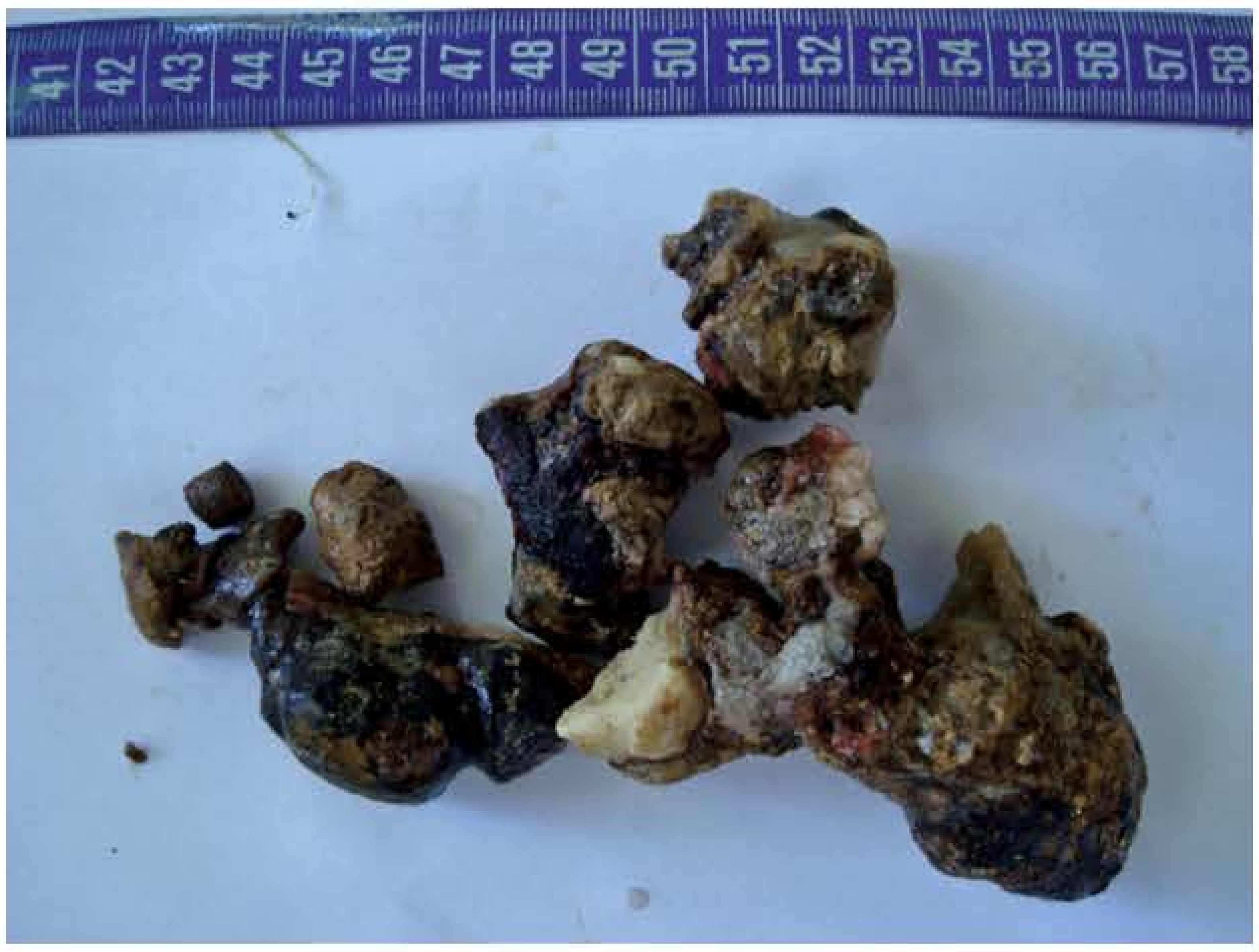


FIGURE 3.3 **Staghorn stone removed by open surgical intervention.**

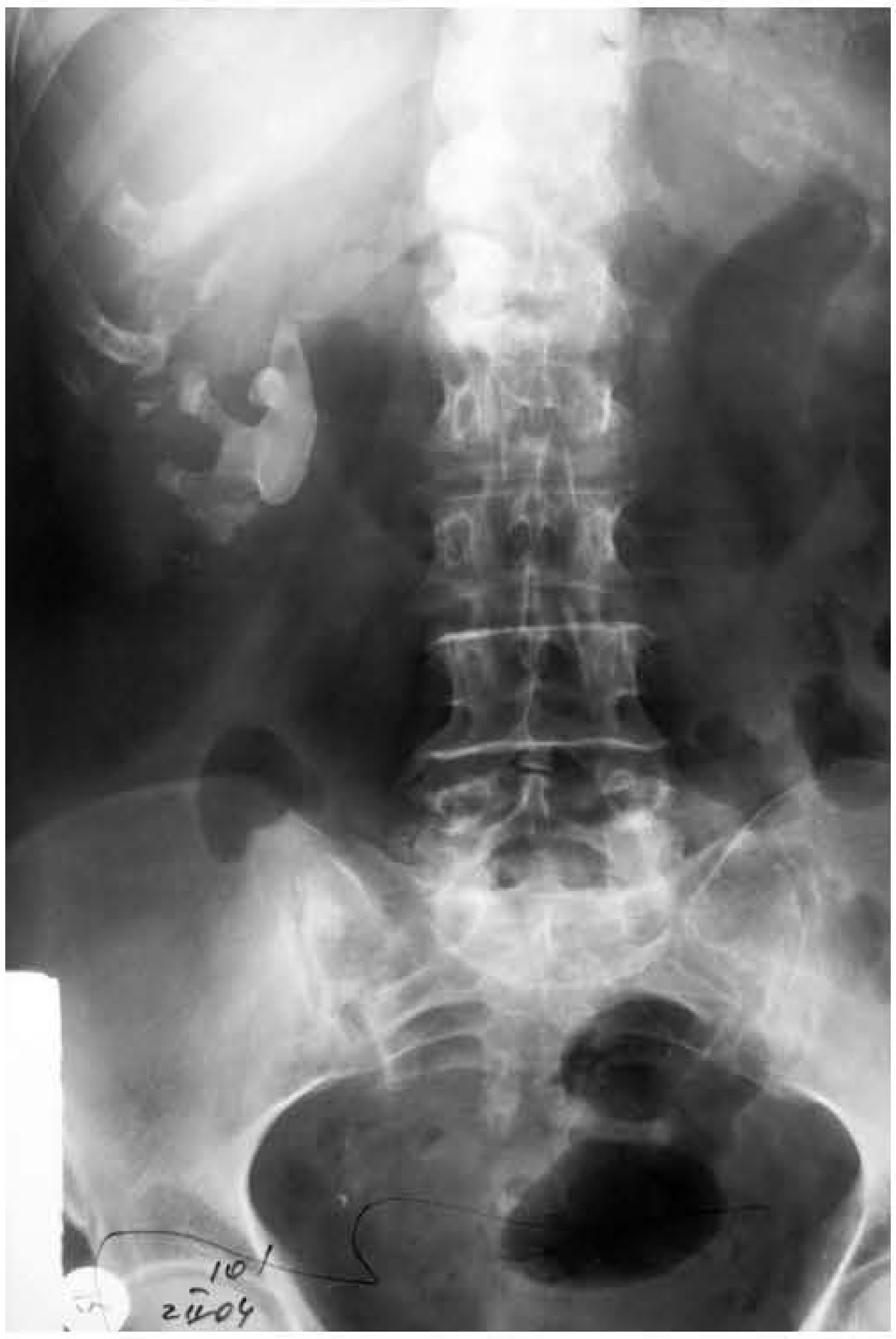


FIGURE 3.4 **Right staghorn stone approached percutaneously.**

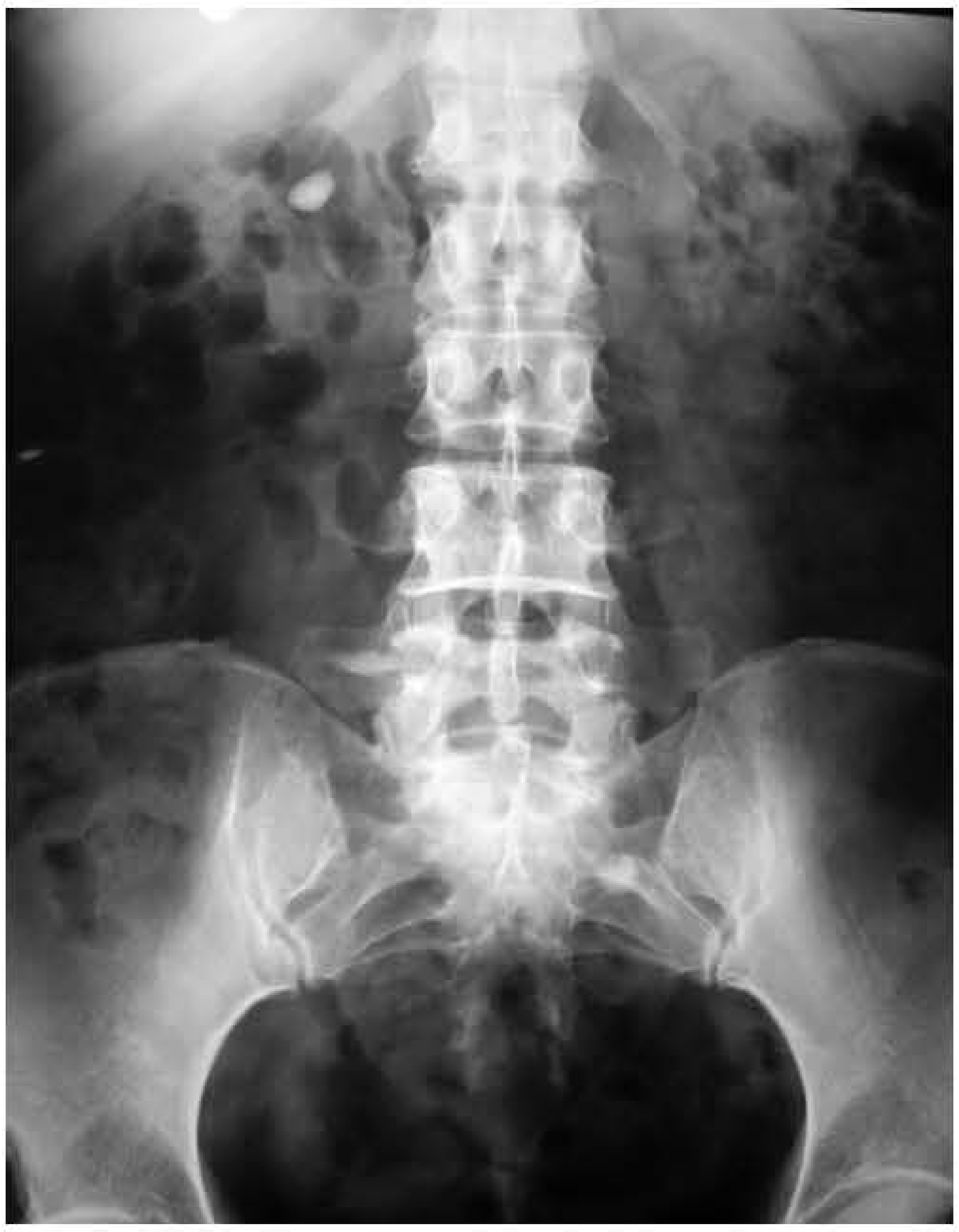


FIGURE 3.5 **Upper caliceal stone smaller than 2 cm.**

monotherapy (Meretyk et al., 1997). The other retrospective studies, although presenting lower differences regarding the success rates, cannot be considered edifying due to the fact that SWL in monotherapy was performed especially in patients with a lower volume of the lithiasic mass (Méndez Probst et al., 2009).

If combined therapy is required, it is recommended that percutaneous nephroscopy be the last procedure of the therapeutic protocol, thus allowing a better assessment of the stone-free status and a higher chance of obtaining this status.

Nephroscopy has proved to have a higher sensitivity compared to simple reno-vesical radiography or nephrotomography for detecting residual fragments (Denstedt et al., 1991). Although nonenhanced computed tomography (CT) is considered the gold-standard method for detecting residual stones (Pearle et al., 1999), the fragments located in the vicinity of the nephrostomy tube may not be discovered by this method. Extracorporeal lithotripsy can be used when the residual fragments cannot be approached by flexible nephroscopy or safely extracted through another puncture tract. However, the complete elimination of fragments after extracorporeal lithotripsy without a subsequent nephroscopy is less probable. Very low stone-free rates have been obtained in the case of combined therapy in which SWL represented the last therapeutic method used. Thus, using this therapeutic protocol, Segura et al. (1987) reported a stone-free rate of only 23%. For stones smaller than 2 cm (Fig. 3.5), excepting those located in the lower calyx, extracorporeal lithotripsy provides very good stone-free rates which confers its position as the first therapeutic modality in the detriment of PCNL (Sahinkanat et al., 2008; Preminger, 2006).

Flexible retrograde ureteroscopy is a viable therapeutic solution, especially for stones smaller than 15 mm. The data published so far have shown a significant reduction in the stone-free rates for larger calculi, although some authors from experienced centers have also reported favorable results for voluminous stones (Türk et al., 2012).

PCNL remains a therapeutic option for stones smaller than 2 cm whose fragmentation could not be obtained by SWL or retrograde approach.

Thus, the stone's chemical composition must be taken into consideration when choosing the therapeutic option, the hardness of the stones affecting the success rates of different types of procedures, especially of extracorporeal lithotripsy (Dretler, 2001). The composition of the stones can be determined by knowing the type of stones eliminated or extracted in case of recurrent lithiasis, the presence of recurrent urinary infections, the urine's acidity, and the radiological aspect (Fig. 3.6).

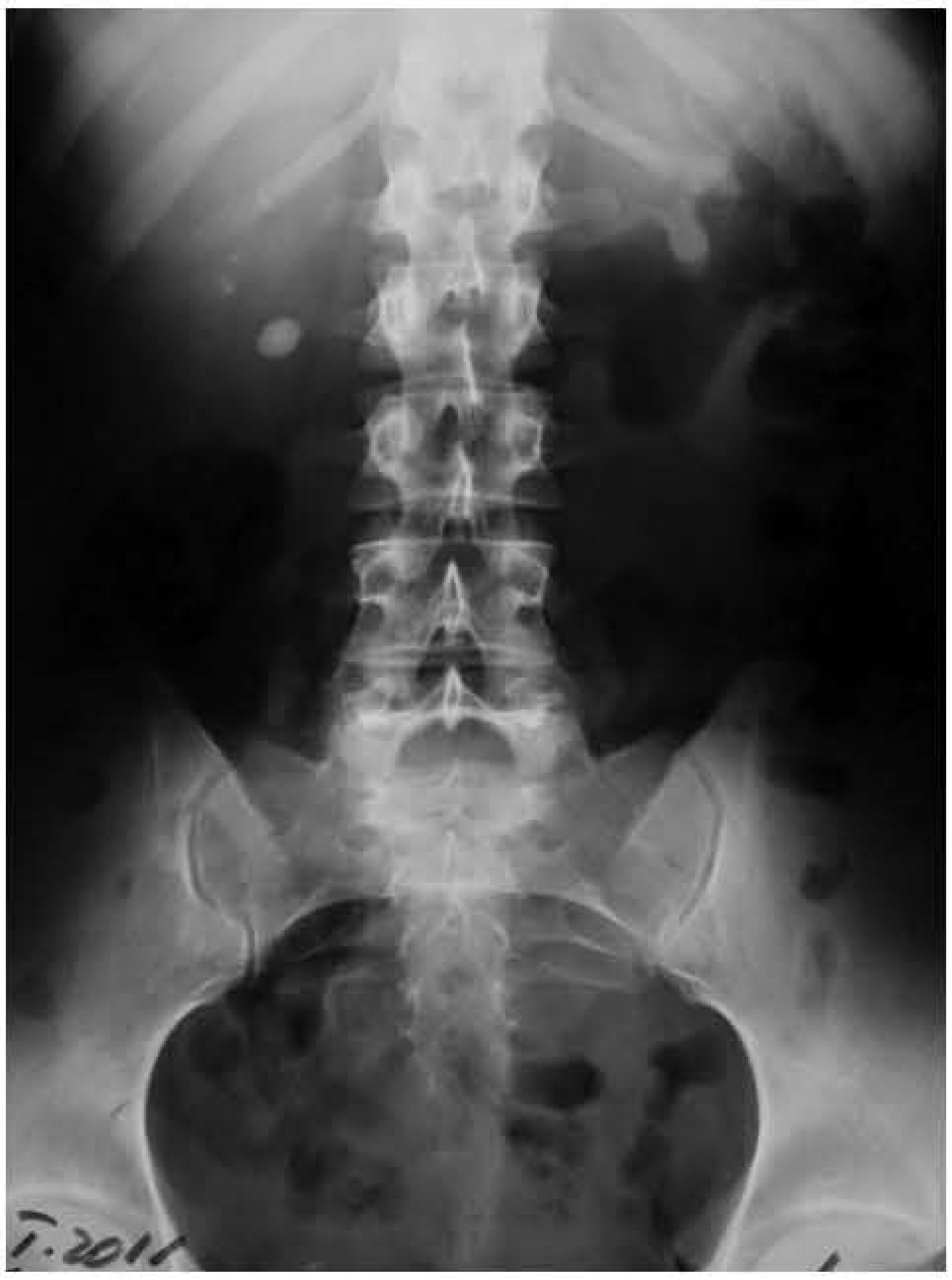


FIGURE 3.6 **SWL-resistant, intensely radiopaque stone.**

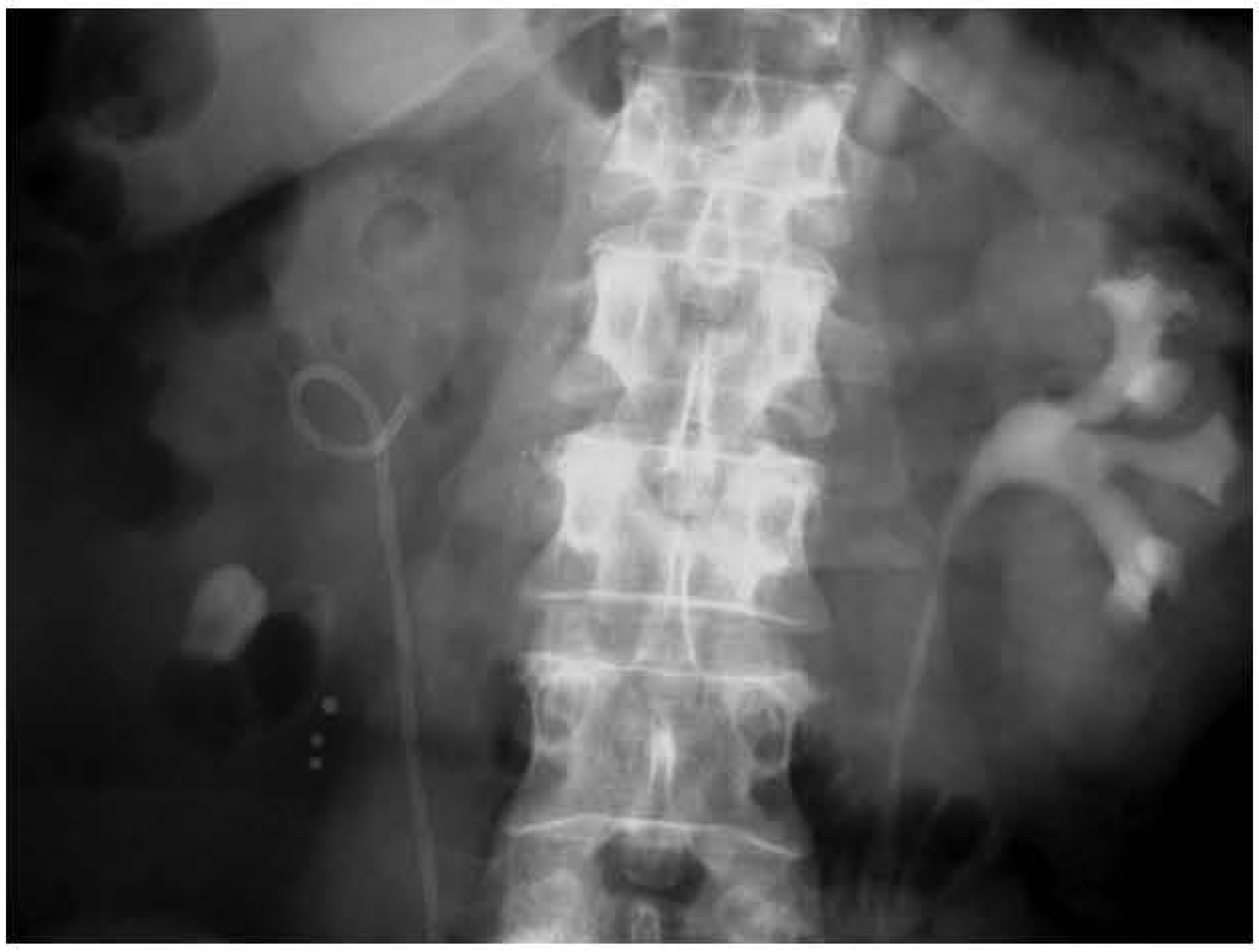


FIGURE 3.7 **Voluminous lower caliceal stone.**

An efficient method for assessing the hardness of stones is represented by CT. A prediction regarding the success of SWL can be made by determining the density of the stones, expressed in Hounsfield units (HU). Thus, Perks et al. (2008) remarked that lithiasis with a density lower than 900 HU has a stone-free rate of over 90%. Cystine, brushite, and calcium oxalate monohydrate stones are included in the category of SWL-resistant lithiasis.

On the other hand, some stones with a reduced resistance are also difficult to treat by extracorporeal lithotripsy, PCNL representing a first-line option. Thus, radiotransparent lithiasis, especially uric acid lithiasis, is difficult to locate by fluoroscopy. Due to its structure, matrix lithiasis cannot be fragmented by SWL, PCNL being the optimal therapeutic alternative. Choosing the therapeutic alternative and the indications for percutaneous approach in case of lower caliceal calculi remains a controversial subject. PCNL is recommended when SWL or flexible retrograde ureteroscopic approach cannot solve the problem. The success rate of these modalities depends in a great measure on the anatomy of the pyelocaliceal system: infundibulo-caliceal angle, length of the caliceal infundibulum, etc. (Geavlete et al., 2008a). These parameters can be determined by intravenous urography or by CT tridimensional reconstruction. For caliceal calculi in which the anatomic configuration does not allow SWL or with a density higher than 500 HU, flexible ureteroscopy is the first indication for stones smaller than 15 mm, the percutaneous approach being recommended for stones larger than 15 mm (Fig. 3.7).

The introduction of instruments for flexible percutaneous approach has diversified the indications for PCNL. The possibility of resolving voluminous, complex lithiasis (Fig. 3.8) through a single puncture tract, in most cases at the level of the lower caliceal group, determines an increase in the stone-free rate with a reduced rate of complications.

3.1.2 Treatment of Renal Lithiasis on Malformed Kidneys

Another situation that raises difficult problems for percutaneous approach is represented by the treatment of renal lithiasis on kidneys with congenital malformations. Thus, regarding the treatment of multiple lithiasis in horseshoe kidneys or in pelvic ectopic kidneys (Fig. 3.9), the difficulties are due to modified relations of the organ and to associated vascular anomalies. Although the puncture of the upper calyx has a low associated morbidity in these patients, this type of approach of stones located in caliceal cavities with an abnormal position (especially in lower calyces with medial orientation) may be difficult, if not impossible, in the absence of the flexible nephroscope.

Also, due to the association of kidney rotation anomalies, the renal pelvis has an anterior position and the length of the nephrostomy tract can exceed that of the rigid nephroscope, requiring the use of the flexible one.

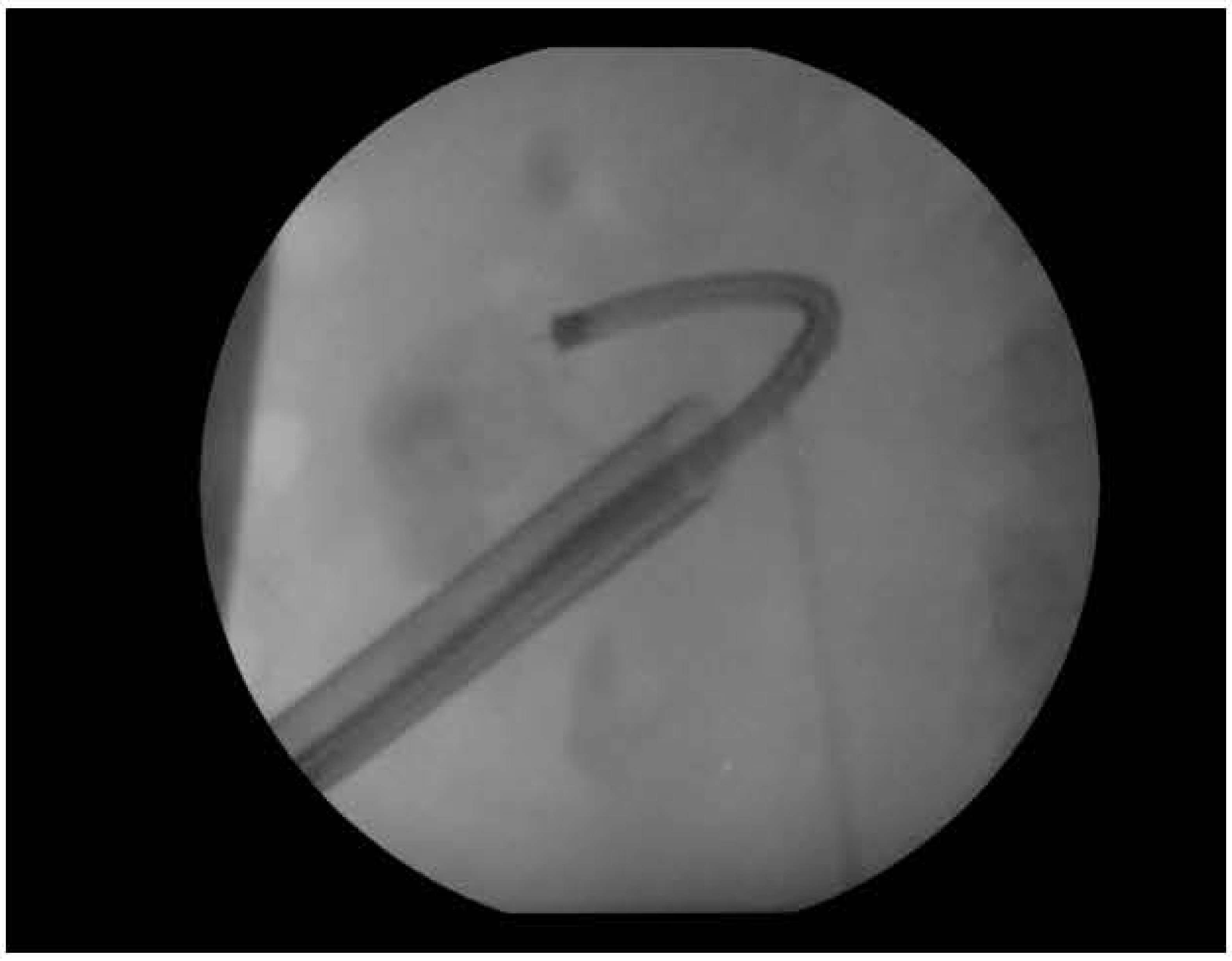


FIGURE 3.8 **Flexible percutaneous approach of multiple renal lithiasis.**

Thus, in a group of 37 patients with lithiasis on horseshoe kidneys treated by PCNL, Raj et al. (2003) reported a stone-free rate of 87.5%, the use of the flexible nephroscope being necessary in 84% of cases. In most situations, due to the particular position of the kidney with the lower pole frequently anteriorized and significantly descended, the puncture tract was performed at the level of the upper calyx (63% of patients).

In a similar study, Al-Otaibi obtained a stone-free rate of 75% (9 of 12 patients) after a single intervention and using a single percutaneous tract, respectively, of 91.7% after second-look interventions. In this study, the use of the flexible nephroscope was essential in 9 of the 11 patients in whom the complete removal of the stones was achieved (82% of cases) (Al-Otaibi and Hosking, 1999).

3.1.3 Treatment of Lithiasis in Caliceal Diverticula

The treatment of intradiverticular lithiasis implies problems in choosing the therapeutic option (Méndez Probst et al., 2009). A study conducted by Auge et al. (2002) showed superior results for percutaneous approach compared to ureteroscopy, regarding both symptomatology (86% vs. 35%) and the stone-free rate (78% vs. 18%) or cavity resolution (61% vs. 18%). Additionally, 41% of the cases treated using ureteroscopy in this group also required percutaneous approach due to the impossibility of identifying the diverticular neck or the residual fragments. Other studies show favorable results for retrograde ureteroscopic treatment (Geavlete et al., 2008b). The disadvantages of PCNL are represented by the 18% rate of complications and prolonged convalescence. On the other hand, extracorporeal lithotripsy led to disappointing results with stone-free rates of 20–60% (Méndez Probst et al., 2009).

3.1.4 Treatment of Renal Lithiasis in Children

A subject of debate has been represented by the site of the percutaneous approach in the treatment of renal lithiasis in children.

PCNL, in monotherapy or associated with extracorporeal lithotripsy, has not been widely used in children due to the higher risk of complications determined by the use of high-caliber instruments. The procedure started being used more and more frequently with the development of low-caliber instruments and ultrasonographic guidance. However, PCNL requires a significant experience of the operator (Desai et al., 2004). Recent data (Bayrak et al., 2012) show that safely performing this intervention in children requires at least 120 procedures performed in adults, and that after approximately 35 cases it can be performed safely and with significant success rates in small children.

Regarding the age at which PCNL can be performed, in a study published in 2011 that assessed the results of PCNL in children below and above the age of 5, Dogan et al. (2011) demonstrated an overall stone-free rate of 86%, being higher in children below the age of 5 compared to older children. Also, the volume of the stones and the number of tracts was higher in children over 5 years of age, while the rate of complications was similar. The resulting data support the fact that age does not represent a limiting factor for the indications of PCNL.

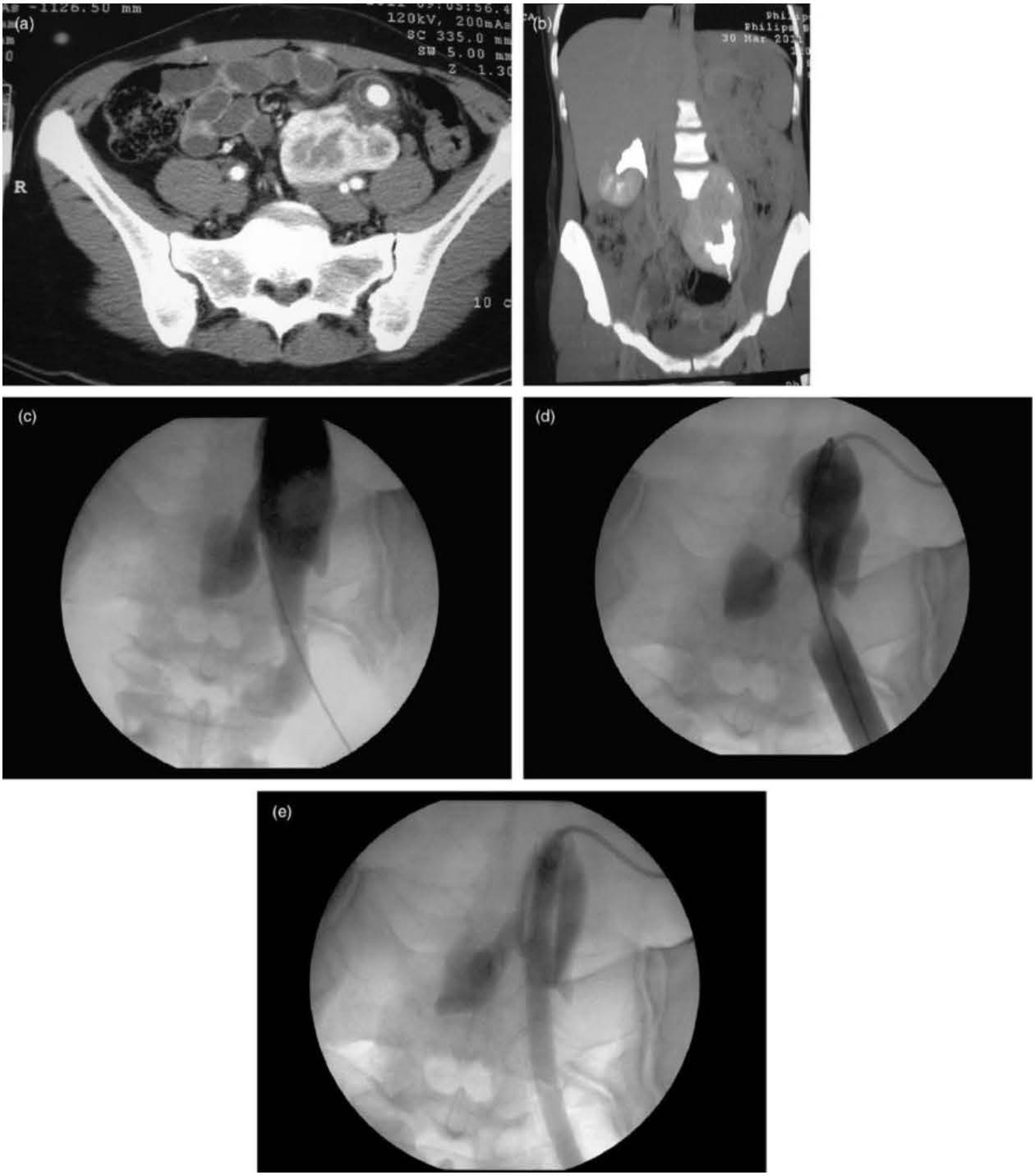

(a)
120kV, 200mAs
SC 335.0 mm
SW 5.00 mm
R
(b)
30 Mar 2011
(c)
(d)
(e)

FIGURE 3.9 **Renal lithiasis in a pelvic ectopic kidney (a, b), approached percutaneously (c–e).**

The main indications for PCNL in children are represented by voluminous pyelocaliceal lithiasis, obstructive lithiasis or associated with infection, radiotransparent or cystine lithiasis, residual stones after SWL, or pyelolithotomy (Boormans et al., 2005; Al-Shammari et al., 1999).

The percutaneous approach also represents a viable alternative for staghorn calculi in children (Kumar et al., 2011). Kapoor obtained a stone-free rate of 83% which, after associating SWL, increased to over 90%. The authors recommend the use of instruments with a caliber lower than 24 F. A detailed preoperative assessment is essential in these patients, approximately 40% of them presenting metabolic or anatomic anomalies (Kapoor et al., 2008).

Through an adequate selection of patients and a careful planning of the procedure, the percutaneous approach can also be used safely in children with lithiasis associated with renal malformations (Abdeldaeim et al., 2011).

To assess the impact of PCNL on the renal parenchyma, a group of 60 children who underwent PCNL was evaluated by renal scintigraphy (Samad et al., 2007). The presence of renal scars at the level of the puncture tract was recorded in 5% of cases. The authors recommended a meticulous technique and the use of adequate instruments for reducing these lesions.

3.1.5 Treatment of Renal Lithiasis on Transplanted Kidneys

Renal lithiasis represents a relatively rare complication of renal transplantation, its incidence being estimated at 0.4–1% (Rhee et al., 1999). The favoring factors for its occurrence are represented by hyperfiltration, excessive alcalinization of the urine, and renal tubular acidosis caused by persistent tertiary hyperparathyroidism.

The location of the transplanted kidney and the modified anatomy of the ureter imply difficulties in treating these cases. Thus, extracorporeal lithotripsy can only be performed with the patient placed in the prone position, the pelvic bones making it difficult to detect the stone (Bhadauria et al., 1995).

Flexible ureteroscopy with laser lithotripsy represents a viable option, but the access to the pyelocaliceal level can sometimes be hindered by the localization of the reimplanted ureter's orifice and its tortuous path.

Due to the transplanted kidney's position next to the abdominal wall, PCNL is a tempting alternative for treating lithiasis. However, this location implies a cautious approach due to the increased risk of injuring the peritoneum or the iliac vessels. The puncture of a transplanted kidney's calyx is more difficult. On the other hand, performing the puncture in a more central position (at the level of the renal pelvis) determines an increase in the risk of arteriovenous fistulas or pseudoaneurysms secondary to excessive bleeding. The use of low-caliber instruments has proved to be a viable and efficient alternative in these cases (He et al., 2007).

3.1.6 Other Factors Involved in the Indication for PCNL

A first category of factors that can influence the choice of PCNL as the therapeutic method for renal lithiasis is represented by occupational factors. Thus, in certain patient groups (pilots, military personnel, etc.) the presence of renal lithiasis, even asymptomatic, does not allow them to continue their activity. These cases require resolving the stones as quickly as possible, without residual fragments, even if more invasive therapeutic methods are necessary. For this reason, PCNL is preferred to SWL (Méndez Probst et al., 2009). In a study conducted on airplane pilots, Zheng et al. (2002) observed a stone-free rate of only 35% and a convalescence period of 4.7 weeks, compared to a stone-free rate of 100% and a convalescence period of 2.6 weeks for PCNL. Obesity also represents an important factor in the therapeutic algorithm of patients with renal lithiasis. The significant reduction of the success rate of SWL in these patients has been demonstrated by many studies (Méndez Probst et al., 2009). Thus, Perks et al. (2008) observed a decrease in the success rate from 79% to 57% in patients in whom the distance between the skin and the stone was longer than 9 cm. Although it may require adapting the instruments and eventually the position by performing the procedure in the supine position, the results of PCNL are not significantly affected by obesity.

Skeletal anomalies can reduce the success rate of SWL, preventing the correct positioning of patients and stone's fragmentation. Although PCNL can be limited by these orthopedic conditions, spinal deformities do not represent a contraindication for PCNL. A correct preoperative assessment can ensure performing the procedure with a high success rate and with low morbidity (Kara et al., 2011).

Although it may imply technical difficulties, PCNL maintains its indications in patients with previous renal interventions, with success rates of 77–95% and rates of complications of 6–12% (Margel et al., 2005; Sofikerim et al., 2007; Kurtulus et al., 2008). Percutaneous surgery may even represent the elective treatment in patients with small caliceal or ureteral calculi when the previous surgical interventions make difficult or even prevent retrograde access (ureteral stenoses, cross-trigonal ureteral reimplantation for vesico-ureteral reflux, urinarydiversions, etc.), especially if the patient already has nephrostomy *in situ* (Méndez Probst et al., 2009).

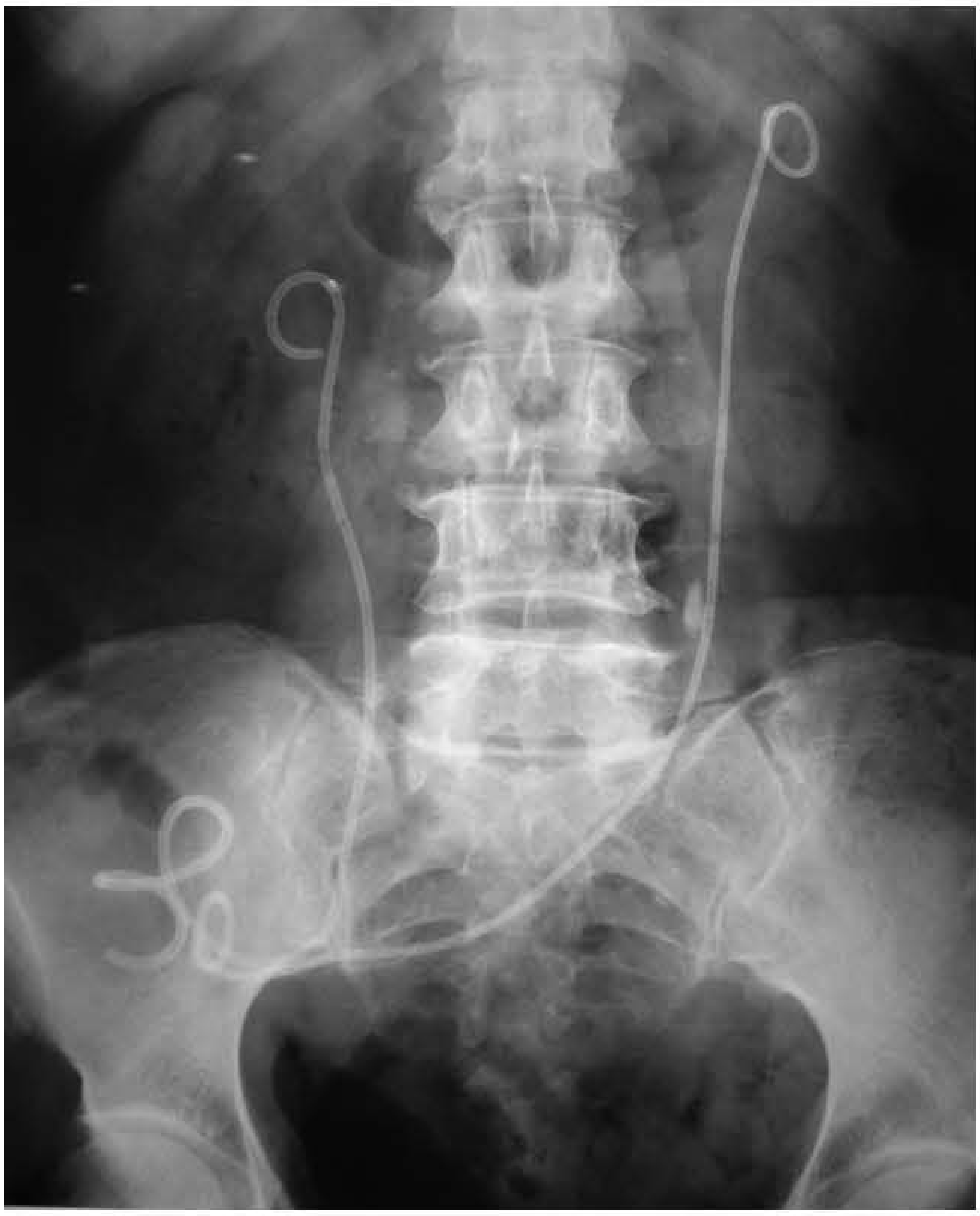


FIGURE 3.10 **Lithiasis on a Bricker urinary diversion.**

The presence of stones in the urinary diversions (Fig. 3.10) occurs in 6–12% of cases. Until the development of flexible retrograde approach, PCNL represented the main therapeutic option with a success rate of 75–100% and an incidence of complications of approximately 12% (Wolf and Stoller, 1991; Cohen et al., 1994; el-Nahas et al., 2006a).

3.1.7 Contraindications

Contraindications for PCNL include those that do not allow general or spinal anesthesia. Besides these, coagulation disorders, due to the increased risk of bleeding, must be resolved before the intervention, and anticoagulant therapy must be stopped. Other major contraindications include (Türk et al., 2012):

- untreated urinary infections
- atypical interposition of the colon
- tumoral masses on the presumed access tract
- suspicion of renal tumors
- pregnancy

In an attempt to avoid hemorrhagic complications associated with the percutaneous approach, modified techniques have been imagined in which the access is achieved using low-caliber tracts. These methods include miniperc, ultraminiperc, and microperc.

Miniperc is addressed especially to calculi with dimensions between 1.5 cm and 2 cm, while ultraminiperc and microperc to those smaller than 1.5 cm. It is interesting that having such indications, the miniaturized percutaneous methods compete with extracorporeal lithotripsy and flexible ureteroscopy. Therefore, we are witnessing a changing paradigm regarding the percutaneous approach, which in the last decade seemed indicated for large pyelocaliceal lithiasic masses. These techniques also have indications in particular situations such as pyelocaliceal diverticula or moderate-size stones in the pediatric population (Ganpule et al., 2015).

In the case of miniperc, the approach implies creating a percutaneous access tract with a caliber of 16–20 F. Mini-nephroscopes, initially developed for pediatric use, are used through these tracts. The Olympus mini-nephroscope has an external diameter of the sheath of 15.9 F, a working channel of 7.5 F, and an optical system of 7°. Similarly, Richard Wolf sells a mini-nephroscope with a sheath of 15 and 18 F and a working channel of 6 F.

3.2 PREOPERATIVE ASSESSMENT

Any surgical intervention, even minimally invasive, requires a detailed preoperative assessment of the patient and a careful planning of each step of the intervention. The initial assessment of patients undergoing PCNL is, up to a point, similar to that of the other surgical interventions and must include a thorough physical exam, complete medical history, and accurate paraclinical investigations. However, several factors must be taken into account to selectively and adequately perform PCNL, especially the localization and dimension of the stone, the patient's habitus, and the anatomy of the upper urinary tract (Stein et al., 2005).

The purpose of the preoperative assessment is to reduce morbidity and to optimize the results of the intervention by identifying patients with contraindications for PCNL, high-risk patients, as well as particular clinical situations that may require modifying or adapting the standard operatory technique and the instruments. From this point of view, special attention should be paid to patients with morbid obesity, patients with previous renal surgical interventions, those with renal anomalies (malrotation, ectopia, horseshoe kidney), patients with a single kidney, and those with transplantation or with pre-existing renal failure (Skolarikos et al., 2005). Knowing exactly the patient's risk factors allows for their preoperative correction, requires increased intraoperative caution, and last but not least, contributes to a reduction in the intervention's morbidity.

Another step in the preoperative preparation is represented by obtaining the patient's informed consent after providing details regarding his disease, the procedure's technique, the potential risks and benefits of PCNL, as well as other therapeutic alternatives, when applicable. The risks of PCNL include injuring adjacent organs, intra- and/or postoperative bleeding, infection, the possibility of a second intervention and, very rarely, conversion to open surgery (Streem, 2006).

3.2.1 Anamnesis

The family medical history, the patient's history of diseases and pharmacological treatments, as well as any prior anesthetic or surgical procedures should be identified before the intervention through an accurate and complete anamnesis. Special attention will be paid to the presence of hematological diseases (coagulopathies), allergies (especially to iodinated contrast agents), as well as valvular heart diseases and respiratory conditions, previous renal surgical interventions, diagnosed malformations of the urinary tract, and cancers. A special category that must be identified during anamnesis is represented by patients who do not accept blood transfusions due to personal or religious reasons (beliefs) (Wen and Nakada, 2007).

Untreated or uncorrected coagulation disorders represent one of the absolute contraindications for PCNL. Intra- or postoperative bleeding is one of the most frequent complications of percutaneous renal surgery, blood transfusion rates of up to 34% being reported in the literature after PCNL. Each kidney receives approximately 5–10% of the systolic cardiac flow, and the risk of severe bleeding occurring during PCNL that can require immediate transfusion, selective arterial embolization, or even nephrectomy is very high in patients with coagulopathies and in those under anticoagulant treatment (Pietrow, 2007).

The number of patients currently under anticoagulant treatment for different diseases (mechanical heart valves, atrial fibrillation, coronary stents) is constantly growing. This group of patients represents a complex clinical situation for the urologist because it requires balancing the risk of bleeding after restarting anticoagulant therapy against the risk of thromboembolic accidents during the period when this treatment is discontinued. Kefer et al. (2009) consider that two important elements regarding interrupting and restarting anticoagulant therapy should be taken into account: the increased risk of thromboembolic accidents during the correction of coagulation and the lack of information regarding the optimal moment for restarting anticoagulant therapy. On the other hand, the risk of thromboses after stopping oral anticoagulants cannot be exactly determined for all patients due to specific conditions imposed by the underlying disease. This risk is higher in patients with mechanical heart valves and in those with atrial fibrillation, and lower in patients with coronary stents (Kearon and Hirsh, 1997; Cannegieter et al., 1995; Fuster et al., 2001; Schünemann et al., 2004). The modality and the moment of interrupting and restarting anticoagulant therapy must be discussed and determined within a multidisciplinary urologist–anethesiologist–cardiologist team, to ensure an optimal regimen for the patient's safety. In this category of patients, considered at high risk, the interruption of anticoagulant treatment will be done after the reassessment and exclusion of other therapeutic alternatives such as sequential ureteroscopy (Gross and Bach, 2009).

A high risk of bleeding during or after PCNL must also be taken into consideration in patients with renal artery atherosclerosis, worsened by certain concomitant diseases, such as diabetes mellitus or arterial hypertension (Patterson et al., 1985). Atherosclerosis affects the capacity of the arterial wall's restoration due to the alteration of its muscular and elastic fibers. Also, the tendency to bleed is higher in patients with liver cirrhosis and in those with uremia, due to the deterioration of coagulation factors which also play an important role in the formation of postoperative pseudoaneurysms and arterio-venous fistulas (Huang et al., 2003).

Previous renal surgical interventions (classic, laparoscopic, or percutaneous) can increase the difficulty of PCNL due to secondary inflammation and fibrosis that they generate and, implicitly, to the possibility of modifying the pyelocaliceal anatomy.

Open abdominal surgical interventions can determine adherence or abnormal interposition of intestinal loops along the tract of PCNL and consequently these may be injured during the procedure. The posterolateral or retrorenal position of the colon was detected during CT scans in approximately 1.9% of patients in supine position. However, the incidence increases to 10% when the patient is in prone position, which is the position most frequently used in PCNL (Hopper et al., 1987). It is very important for the safety of the intervention to detect this particular anatomic situation before performing any renal percutaneous procedure.

Hadar and Gadoth (1984) and Sherman et al. (1985) reported the retrorenal position of the colon in approximately 0.6% of the general population. Patients with a high risk of injury to the colon during PCNL are also those with horseshoe kidneys or with other forms of renal fusion, with ectopia or colonic distension due to a jejuno-ileal by-pass, partial jejuno-ileal by-pass, neurological dysfunctions, etc. Preoperative CT assessment is recommended in high-risk patients, while in some cases, achieving percutaneous access under CT guidance should be considered (Matlaga et al., 2003).

The risk of renal trauma while creating the percutaneous tract must also be taken into account in patients with a history of repeated renal infections, in whom retroperitoneal inflammation may lead over time to attachment of the kidney (Carson, 1986).

3.2.2 Physical Examination

The physical exam represents the oldest and the most frequently used diagnostic method. Besides the medical history, the complete and detailed physical exam represents an essential component of the urological patient's evaluation which must not be neglected, despite the current trend to base our diagnosis predominantly on the multitude of modern imagistic and laboratory diagnostic methods (Gerber and Brendler, 2007).

Inspection provides information on the patient's nutritional status (obesity, cachexia), on the existence of skeletal anomalies, or may reflect the presence of postoperative scars that should be correlated with the information obtained from the medical history.

Cachexia frequently suggests the existence of cancer, while obesity may be the consequence of endocrinological diseases (Gerber and Brendler, 2007).

The postural changes generated by conditions such as severe scoliosis or muscular contractures can influence the operatory indication or the PCNL technique due to the limits related to patient positioning or to the site of the percutaneous access (Méndez Probst et al., 2009). Also, the detection during the physical exam of a lumbar mass suggesting a tumoral mass or of an eventration along the presumed tract of the percutaneous access requires either additional investigations or reassessment of the indication for percutaneous approach.

3.2.3 Laboratory Investigations

The minimal (routine) laboratory investigation of patients selected for PCNL must include complete blood count, coagulation tests, renal function tests and serum electrolytes, glycemia, urinalysis and urine sediment, and uroculture.

Complete blood count represents a mandatory test that must be performed before any percutaneous intervention. Knowing the initial levels of the hemoglobin and hematocrit has a major importance in the patient's management if significant bleeding occurs (Grasso, 2011). When a laborious, difficult intervention is expected or when factors that may increase the risk of intra- or postoperative bleeding are identified, it is recommended to determine the blood group and Rh of the patient in case of possible transfusions.

The number of leukocytes may indicate the presence of a concomitant infectious process which requires a more aggressive preoperative antibiotic prophylaxis (Grasso, 2011). The coagulation profile includes prothrombin time, activated partial thromboplastin time (APTT), number of thrombocytes, and INR. Because one of the absolute contraindications of PCNL is represented by coagulation disorders, their preoperative detection and correction is essential.

Correction by interrupting anticoagulant medication or by administering fresh frozen plasma is required when the APTT and INR are 1.5 times higher than the normal values. Because the effect of coagulation correction after administering plasma lasts approximately 6 h, the procedure must be performed within this timeframe. Thrombocyte mass transfusion is required when their level is lower than 80,000 dL^{-1}.

3.2.4 Electrocardiogram

The electrocardiogram (ECG) is part of the preoperative investigation protocol for most surgical interventions. There are contradictory opinions in the literature regarding the advantages of routinely performing this investigation before the intervention and there is no absolute consensus regarding the categories of patients in whom ECG is mandatory.

Performing preoperative ECG in healthy, asymptomatic patients is based on the presence of two cardiovascular risk factors: age and male gender. Most guidelines recommend preoperative ECG assessment in male patients over 45–50 years old and in women over 50–55 years old. In younger patients, ECG is required only when anamnesis identifies additional cardiovascular risk factors such as arterial hypertension, diabetes mellitus, morbid obesity, severe peripheral vascular disease, hyperlipidemia, coronary disease or arrhythmias, smokers, family history of sudden death or myocardial infarction, and severe cardiac or pulmonary diseases. ECG is also recommended in patients under treatment with tricyclic antidepressants, diuretics, or for drug abusers.

Anomalies detected on the ECG that may determine performing additional investigations are represented by rhythm and conduction disorders, atrial fibrillation and flutter, left ventricular hypertrophy, premature ventricular contractions, WPW syndrome, and signs of ischemia or infarction.

3.2.5 Imagistic Evaluation

Choosing the optimal method for managing urinary lithiasis depends on the size and location of the stone, as well as on the clinical symptoms. Preoperative planning plays an essential role in identifying the position and number of the stones, and in assessing as accurately as possible the pyelocaliceal system's architecture and the relations of the kidney with the adjacent organs (Yuhico and Ko, 2008). The most frequently used imagistic methods for evaluating the patient with renal lithiasis are represented by simple reno-vesical radiography (SRVR), ultrasonography, intravenous urography (IVU), and CT exam in its different variants.

SRVR remains the first imagistic investigation requested in patients with suspicion of urinary lithiasis. It has the advantage of being easy to perform, is accessible and inexpensive, but has a sensitivity of only 58% and a reduced specificity of only 69% for the diagnosis of renal stones (Yuhico and Ko, 2008). In patients with renal colic, SRVR has a sensitivity of 60–70% and a specificity of 70–80% in detecting stones compared to CT exam, its accuracy being, however, lower in patients without renal colic (Bradley and Rao, 2011). The sensitivity of SRVR in detecting urinary calculi varies between 45% and 58% when nonenhanced CT is used as a reference standard (Breiman and Coakley, 2007). The association of nephrotomography may improve this percentage by approximately 30–40%, but at the cost of a significant increase in the irradiation dose of the patient, while the general accuracy of SRVR remains significantly lower than that of CT examination (Breiman and Coakley, 2007).

The detection of stones on conventional radiographies depends not only on their size and composition, but also on some factors related to the technique, the patient's habitus, or the adjacent structures superposed on the urinary tract (intestinal content). Theoretically, approximately 90–95% of stones are radiopaque enough to be detected by SRVR (Breiman and Coakley, 2007). However, in practice there are limitations of SRVR in assessing patients with renal lithiasis generated either by the multiple false images that can mimic renal lithiasis (biliary calculi, calcified mesenteric lymph nodes, phleboliths), by the possibility of not identifying the stones (radiotransparent stones, masked by the intestinal content or by the adjacent bone structures), or by the lack of ability to delimit the kidney, the pyelocaliceal system, or the adjacent organs (Yuhico and Ko, 2008). Performing films with an oblique incidence or from profile may sometimes establish the diagnosis by differentiating renal calculi from other radiopaque images. The use of exposure techniques with low kilovoltage (60–70 kV) allows increasing the contrast between calculi and adjacent soft tissues, while higher doses are necessary in overweight patients (70–80 kV) in order to avoid underexposure (Bradley and Rao, 2011).

Ultrasonography is used for the diagnosis of renal stones (Fig. 3.11), the assessment of hydronephrosis secondary to ureteral obstruction, or for guiding some therapeutic maneuvers such as extracorporeal lithotripsy, percutaneous nephrostomy, or creating the PCNL tract. Moreover, it allows evaluation of the thickness of the renal parenchyma and identification of radiotransparent calculi.

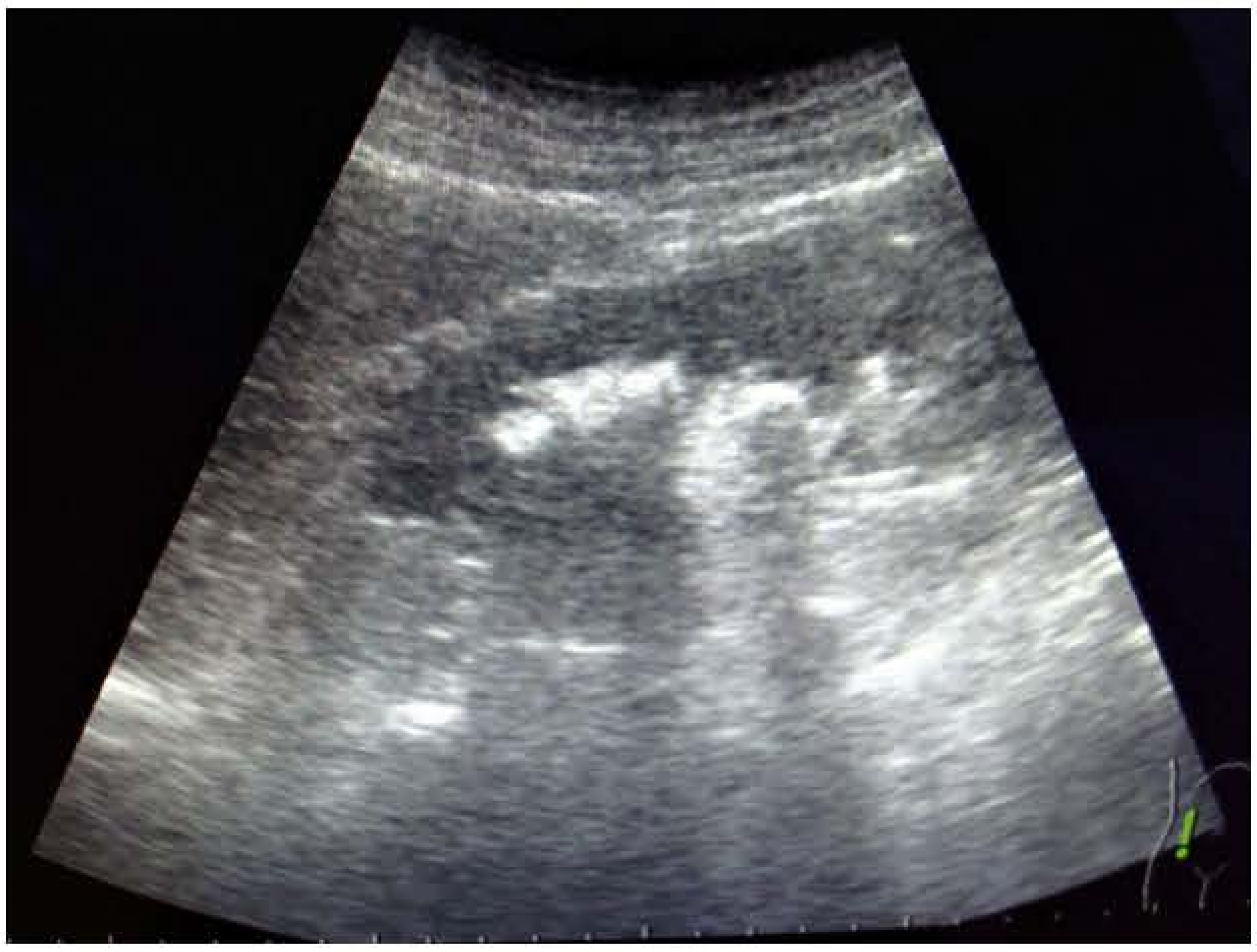


FIGURE 3.11 **Left staghorn stone (ultrasonographic aspect).**

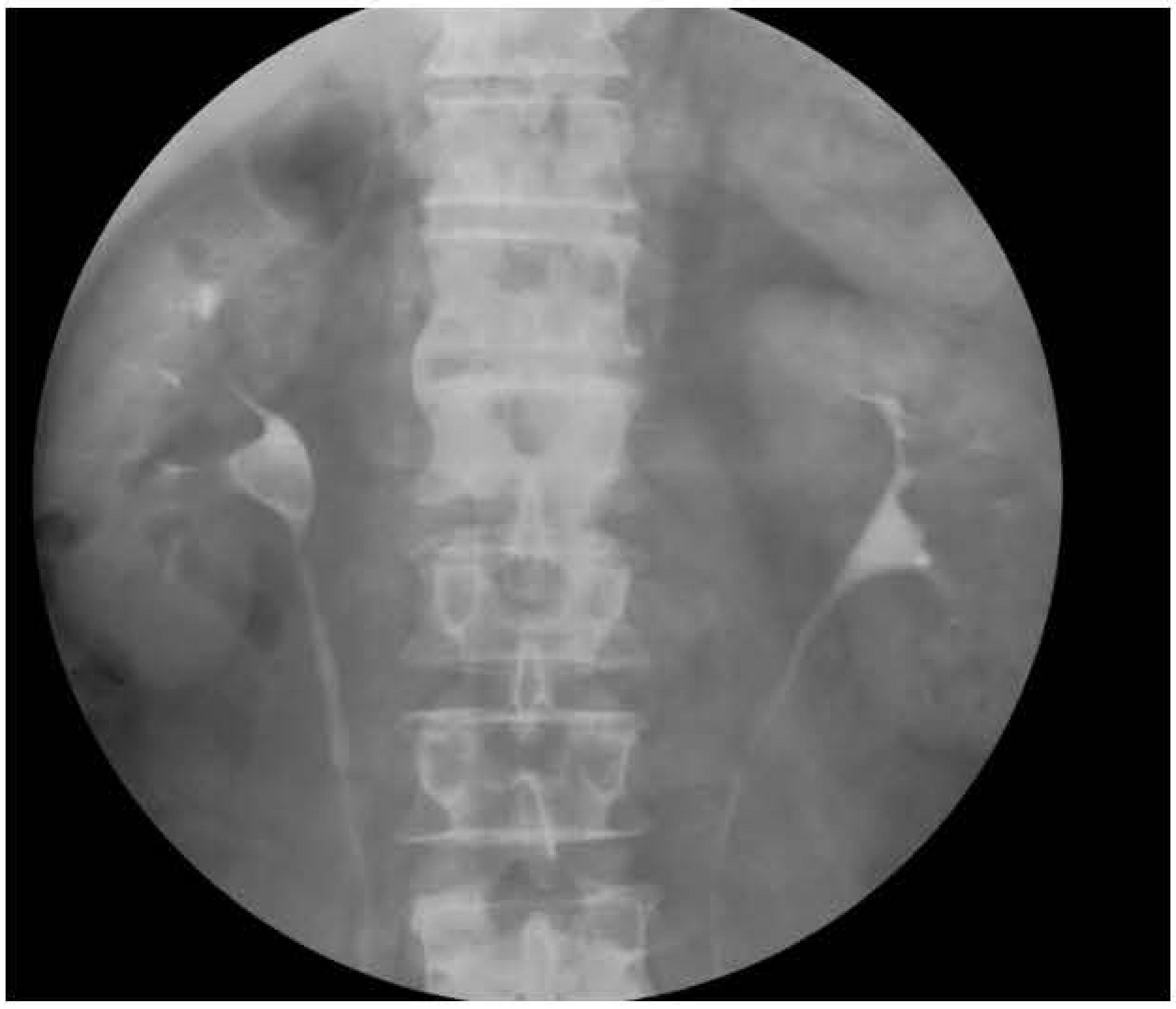


FIGURE 3.12 **Radiotransparent pyelic stone (IVU aspect).**

Ultrasonography has the advantage of being an inexpensive, rapid, widely accessible, repeatable, and safe method (it does not imply the risk of contrast agents or of irradiation; it does not have contraindications or complications) and that allows a real-time assessment of the urinary tract. The method's disadvantages consist of a limited diagnostic accuracy compared to CT, the impossibility of evaluating the ureter (with the exception of a small segment of the proximal and distal ureter), as well as the fact that unlike the other imagistic methods, it is dependent on the operator.

In a comparative study that considered nonenhanced CT as the gold standard for diagnosis, ultrasonography detected only 24 of 101 renal stones, with a specificity of 90% (Breiman and Coakley, 2007; Fowler et al., 2002).

The rate of false-negative results of ultrasonography in the diagnosis of patients with acute renal colic varies in the literature between 6% and 38%, representing a significant diagnostic limitation for this imagistic method. The use of Doppler ultrasonography can improve the rate of diagnosis of renal obstruction in the absence of dilation by assessing the renal resistive index, which is increased secondary to the increased vascular resistance in the obstructed kidney. The resistive index represents the ratio between the intrarenal diastolic and systolic arterial flow, and in the case of renal obstruction the value of this index is higher than 0.7.

The combination of SRVR-ultrasonography has been described by several authors as having an increased specificity and sensitivity compared to each method used alone. However, given the limitations described for each method, this has not been confirmed in practice, more realistic studies reporting a sensitivity rate of 80% and a specificity of 58% (Breiman and Coakley, 2007).

Until the appearance of CT, IVU represented the gold-standard method for assessing urinary lithiasis. Even at present, when spiral, multidetector CT, or urotomography are more and more widely used, IVU continues to play an important role in the diagnosis of urinary lithiasis. It is an accurate and relatively safe method for identifying and characterizing stones, and it provides additional information on the urinary tract's anatomy and renal function. IVU can document urinary tract anomalies that favor lithogenesis or that can influence the choice of the therapeutic method, as well as radiotransparent calculi that appear as contrast medium filling defects at different levels of the urinary tract (Fig. 3.12).

The location and dimensions of the stone can be assessed, as well as the degree of obstruction determined by it, and intraluminal opacities can be differentiated from extraluminal ones (Breiman and Coakley, 2007).

Another advantage of IVU (Fig. 3.13) refers to the fact that it allows determination of the relations of the pyelocaliceal system with the last ribs and, implicitly, the possibility to plan the supracostal approach.

The main disadvantage of IVU is represented by the risk of occurrence of adverse reactions to contrast agents. The existence of a documented allergy to the contrast agent represents an absolute contraindication for IVU. The development of noniodinated contrast agents, with low osmolality, has reduced the risk of triggering adverse reactions by approximately 80%.

Patients with an altered renal function present an increased risk of nephrotoxicity triggered by the contrast medium, especially those with diabetes mellitus.

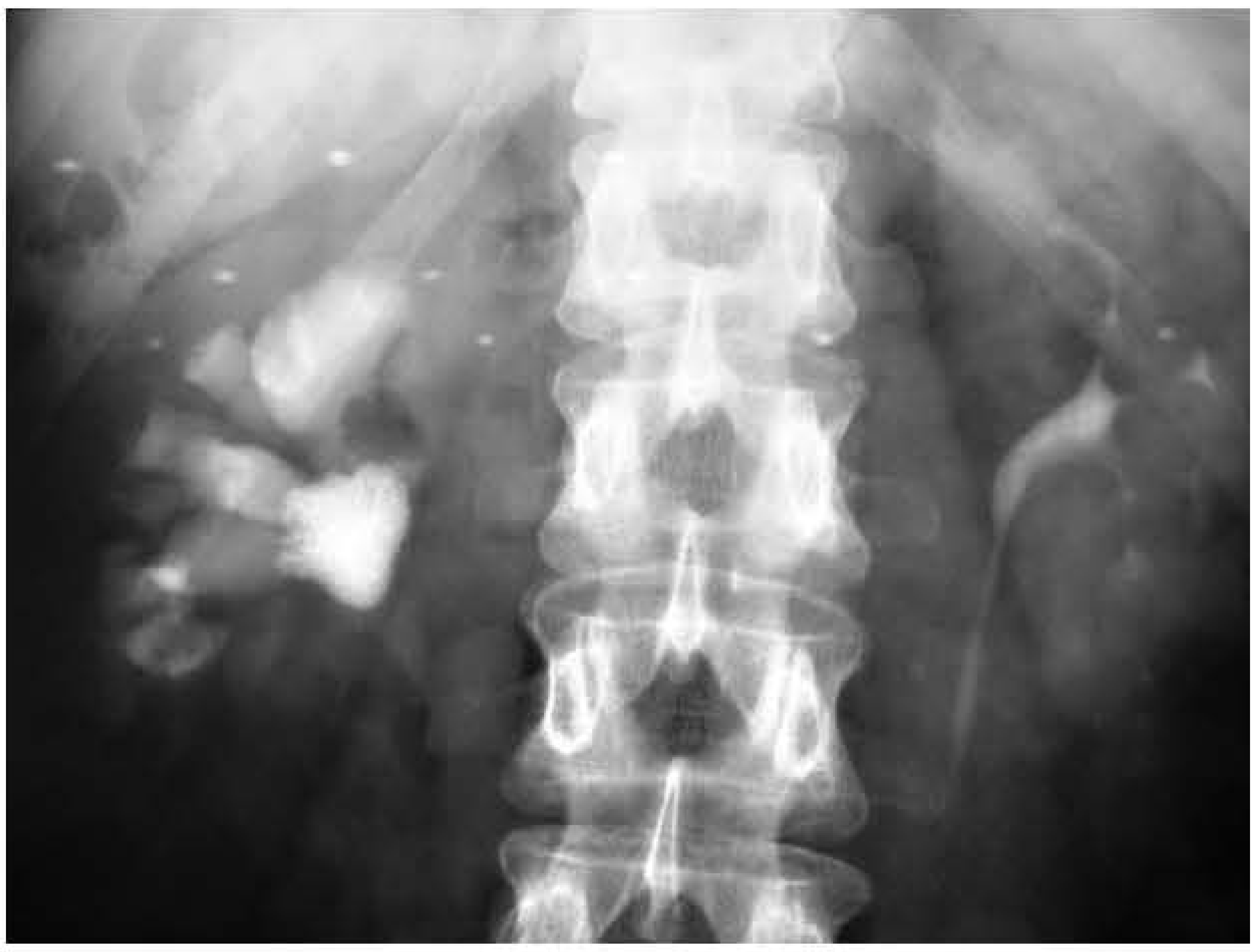


FIGURE 3.13 **Voluminous right pyelic stone (IVU aspect).**

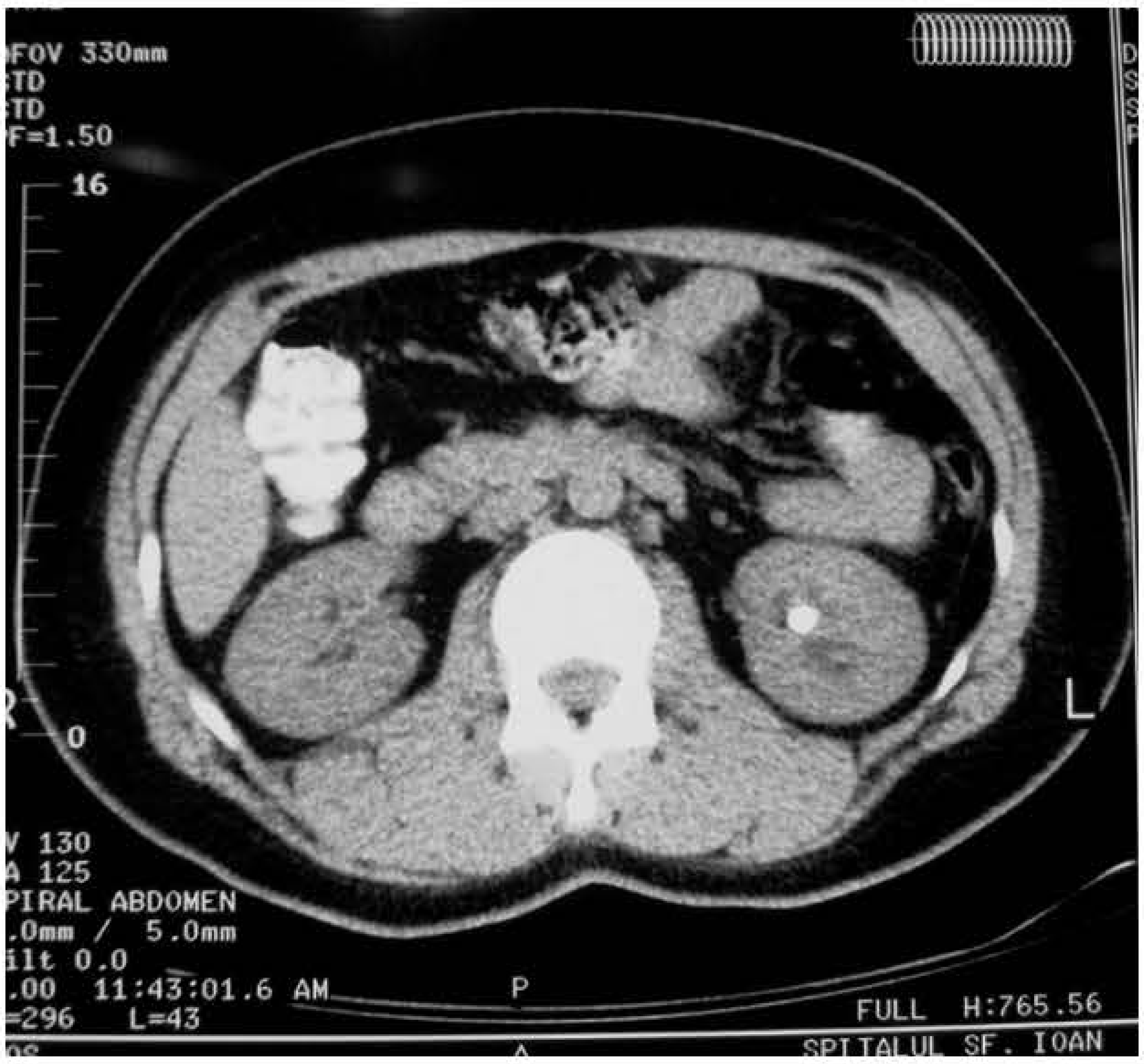


FIGURE 3.14 **Left pyelic stone (CT aspect).**

Another disadvantage is related to the difficulties encountered in patients with severe renal obstruction, in whom the investigation can be prolonged to obtain the late images necessary for a complete evaluation.

Nonenhanced *CT* is currently considered the gold standard of imagistic diagnosis for urinary lithiasis because it can detect and localize almost 100% of calculi, regardless of their composition (Fig. 3.14).

The only exceptions (very rare) are represented by some stones formed in association with medications that excrete protease inhibitors (indinavir) or by those composed only of mucous matrix and tissular debris (pure matrix calculi). Practically, the terms radiotransparent and radiopaque which apply in the case of SRVR are no longer useful in the case of CT scans. Nonenhanced CT cannot accurately establish the degree of obstruction and cannot estimate its duration; it can, however, detect small calculi, superposed on bone structures or lithiasis occurring in urinary diversions.

The method can describe in detail the renal anatomy, including patients with ectopic, malrotated, or horseshoe kidneys, as well as in those with morbid obesity or spinal deformities. Also, the retrorenally situated colon can be diagnosed by CT. CT-guided renal puncture has indications in a selected group of patients, such as those with ectopic kidney, retrorenal colon, ileal reservoirs, severe spinal dysmorphism, or important hepato- or splenomegaly. The lack of using contrast agents avoids the risk of adverse reactions in allergic patients or of acute deterioration of renal function in patients with renal failure. Besides these advantages, quantification in HU of the stone's opacity allows evaluation of its composition and implicitly its hardness, with direct implications in the therapeutic indication and on the modality of lithotripsy. Tomography also allows the diagnosis of other nonlithiasic diseases of the urinary tract such as tumoral masses, pyelonephritis, etc., but also of other extraurinary causes responsible for the appearance of pain in the flank or abdomen. It is a rapid technique, easy to perform, and does not require the patient's prior preparation. CT allows examination of the entire abdomen and pelvis within a single scan with the patient in apnea, and using modern multidetector helicoidal tomographs, the acquisition time of 20 slices is approximately 20 s (Johri et al., 2010; Breiman and Coakley, 2007).

The development of spiral CT revolutionized the imagistics of urinary tract lithiasis, imposing itself as an extremely accurate modality for identifying renal calculi. In a comparative study performed in a group of 40 patients with flank pain, 28 of whom with proven lithiasis, nonenhanced CT exam demonstrated a sensitivity of 100% and a specificity of 92% compared to 64% and, respectively, 92% recorded for intravenous urography. In general, the sensitivity reported for CT in detecting urinary stones varies between 97% and 100%, while specificity varies between 92% and 100% (Hartman et al., 2006). The disadvantage of CT exam compared to IVU is the lack of details regarding the functional component of the kidneys. However, the exact evaluation of the duration and severity of the obstruction does not contribute significantly to the therapeutic decision or the intervention's success (Breiman and Coakley, 2007).

Contrast-enhanced tomography or urotomography has recently imposed itself as the most complete method for assessing patients with urinary tract diseases. Classically, the method consists of a succession of 3–4 CT acquisitions of the abdomen, of which the first is performed without contrast medium and the following after bolus injection of the contrast medium. These last three acquisitions are divided into an arterial phase (5 s after injection), a venous or parenchymal phase (at approximately 100–120 s after injection), and an excretory phase (12–15 min after injection). The excretory phase represents the essential step of the uroCT protocol because it highlights the spatial conformation of the urinary tract and especially the position and orientation (anterior or posterior) of all caliceal groups. The two vascular phases (arterial and venous) can be combined into a single one by making a single cliche several seconds after injection. Each of the four phases of the uroCT described contributes equally to planning the PCNL. The cliche without contrast medium identifies the position of the renal stones, while the vascular phase explores the renal parenchyma and provides details on the main intrarenal vascular branches, information which is extremely useful in establishing the therapeutic indication and especially the renal approach tract (Dillenseger et al., 2003).

A newer and more sophisticated variant of the CT exam consists of tridimensional (3D) reconstruction of the standard axial images (Fig. 3.15). The technique depends much less on the operator and allows a detailed description of the pyelocaliceal system compared to the conventional, bidimensional variants. The 3D images specify not only the location, number, and dimensions of the stones, but most important, they offer details regarding the spatial orientation of the caliceal groups and the angles between them. This information is extremely useful in choosing the optimal therapeutic alternative and the ideal tract in difficult cases (patients with morbid obesity, malrotated hypermobile kidney, staghorn calculi). The disadvantage of this method consists of the high cost and reduced accessibility, 3D-CT having the indication of a method for planning PCNL only in selected cases (Thiruchelvam et al., 2005).

Magnetic resonance imaging (MRI) provides a higher contrast resolution compared to CT, but a lower spatial resolution. The indication for MRI in the diagnosis of urinary lithiasis is addressed especially to selected cases, such as pregnant women or children, cases in which avoidance of exposure to radiation represents an absolute priority, or in patients with documented allergy to contrast agents. The main disadvantage of MRI in assessing stones consists of the fact that these appear as a lack of signal (black background) on the background of the signal with increased intensity generated by the urine from the urinary tract, which makes it difficult to detect or to differentiate from similar images provided by blood clots or tumors. The exploration of the urinary tract by MRI can be done with static or dynamic techniques.

The main indication of static MRI is to highlight hydronephrosis in pregnant women with flank pain, where it can differentiate between obstruction due to uterine compression and that due to a stone. This method provides detailed information regarding the urinary tract's anatomy and has a high sensitivity in highlighting the signs secondary to ureteral obstruction, such as the presence of perirenal fluid.

Dynamic or excretory MRI is an imagistic technique similar to IVU or contrast-enhanced CT and consists of intravenous administration of a gadolinium-based contrast medium together with 5 mg of furosemide. The diuretic improves the dilution of the contrast medium and its uniform distribution in the urinary tract. Dynamic MRI can be performed only in the case of a normal or slightly impaired renal function because administration of gadolinium in patients with significantly impaired renal function is contraindicated due to the risk of systemic nephrogenic sclerosis. The sensitivity and specificity reported for dynamic MRI in the diagnosis of urinary stones is of 96% and, respectively, 100%, similar to the CT scan (Bradley and Rao, 2011).

Renal nuclear (isotopic) imagistic studies (Fig. 3.16) do not play a role in the diagnosis of urinary lithiasis. The purpose of these investigations is to establish the preoperative differential renal function and to assess the degree of obstruction. The preoperative assessment of the renal function contributes to the decision of the therapeutic alternative. Thus, in some cases, PCNL can be postponed until the renal function improves after urinary tract drainage, while in the case of a kidney with a compromised function (below 15–20%) the decision can be made to perform nephrectomy (Bradley and Rao, 2011).

Retrograde or antegrade pyelography does not play an important role in the diagnosis of renal lithiasis. It is useful especially in azotemic patients or in those in whom intravenous administration of the contrast medium is contraindicated or produces an insufficient opacification of the urinary tract. Another indication is represented by patients with a clinical suspicion of urinary lithiasis, but in whom the other diagnostic methods did not detect the presence of calculi. Besides its limited diagnostic role, retrograde pyelography represents the initial operatory step in PNL, the puncture of the pyelocaliceal system and creation of the percutaneous tract usually being performed under fluoroscopic guidance.

Antegrade pyelography is useful when retrograde approach is not possible and when decompression of the pyelocaliceal system is necessary in patients with severe obstruction and associated infection. In both cases it is recommended to inject a diluted contrast medium, with low pressure in order to prevent overdistension and leakage, and in infected patients to avoid the risk of sepsis (Breiman and Coakley, 2007).

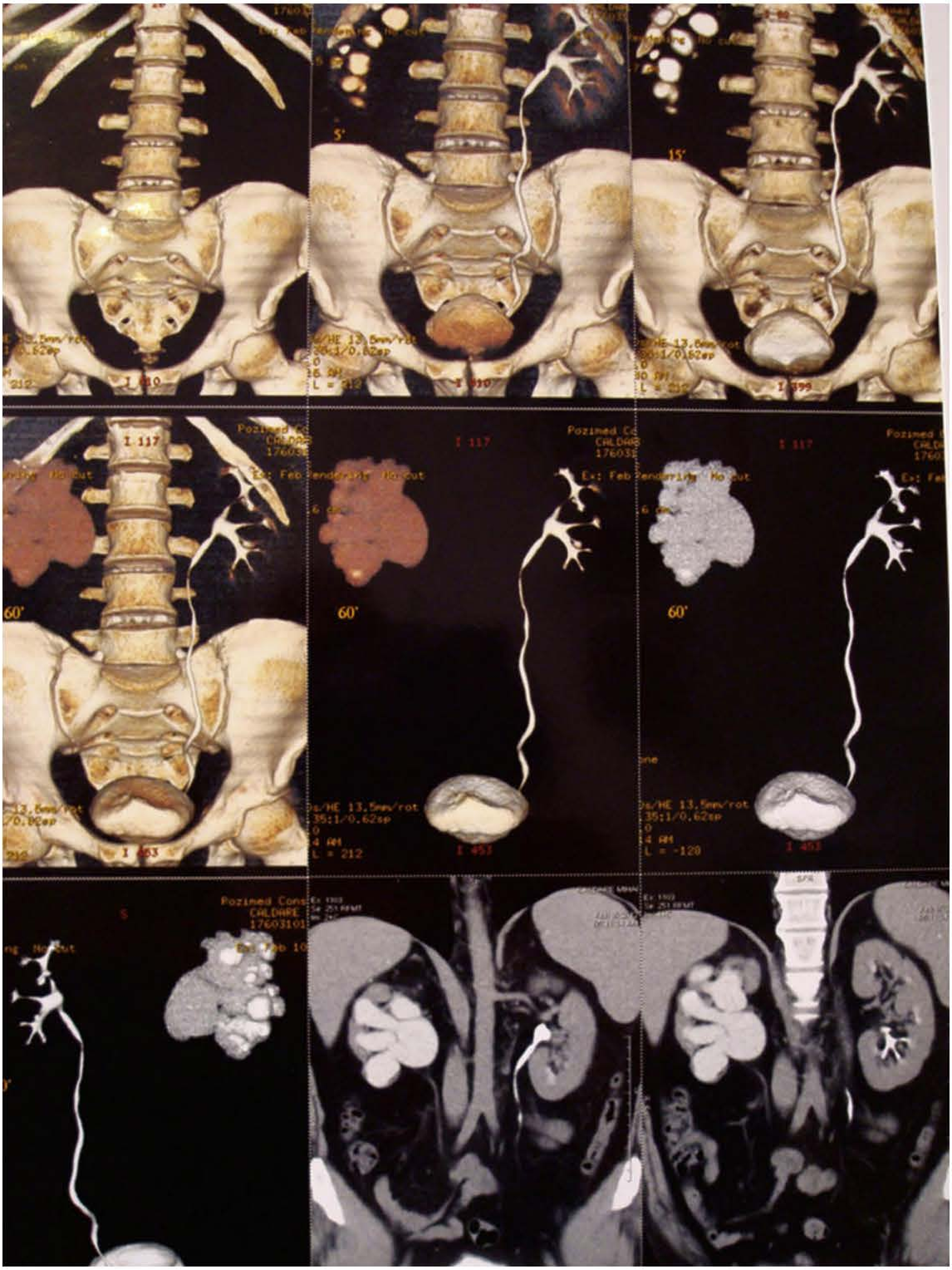
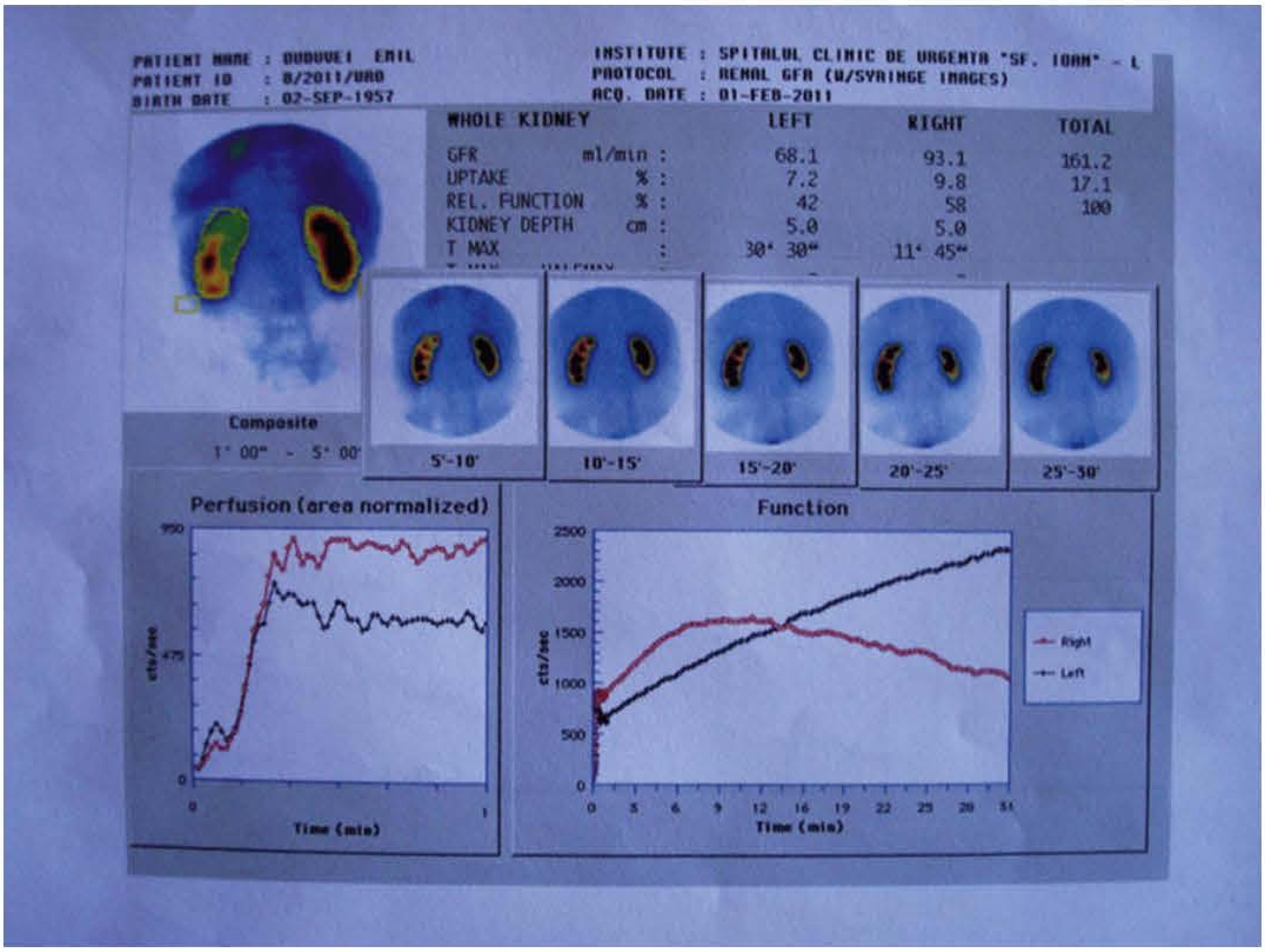


FIGURE 3.15 UroCT with tridimensional reconstruction.



PATIENT NAME : OUDUVEI EMIL
PATIENT ID : 8/2011/URO
BIRTH DATE : 02-SEP-1957

INSTITUTE : SPITALUL CLINIC DE URGENTA "SF. IOAN" - L
PROTOCOL : RENAL GFR (W/SYRINGE IMAGES)
ACQ. DATE : 01-FEB-2011

WHOLE KIDNEY		LEFT	RIGHT	TOTAL
GFR	ml/min :	68.1	93.1	161.2
UPTAKE	% :	7.2	9.8	17.1
REL. FUNCTION	% :	42	58	100
KIDNEY DEPTH	cm :	5.0	5.0	
T MAX	:	30' 30"	11' 45"	

FIGURE 3.16 Renal scintigram with isotopic nephrogram.

3.2.6 Patients at Risk

There are situations in which the comorbidities of patients with renal lithiasis who will undergo PCNL require additional precautions, a more laborious preoperative preparation, and/or adaptation of the operative technique. Moreover, due to increased risks, some of these particular cases are considered by some authors as relative contraindications for PCNL (Pietrow, 2007). The preoperative knowledge of the risks, limitations, and technique modifications imposed by this category of patients contributes essentially to the significant reduction in PCNL morbidity.

The percutaneous approach in patients with horseshoe kidneys, malrotated kidneys, or pelvic ectopic kidneys is considered an efficient and relatively safe technique, especially in cases with voluminous calculi and/or associated pyeloureteral junction stenosis. The main fear in such cases is related to the impossibility to achieve the puncture or the risk of injuring the adjacent organs or the renal vessels with a modified trajectory. Detailed preoperative imagistic investigations (CT, uroCT, or 3D) and the renal approach at the level of the upper or middle calyces prevent the occurrence of these complications. In patients with pelvic ectopic kidneys, performing classic PCNL under fluoroscopic guidance is possible only in some cases due to the high risk of injuring the adjacent organs. Ultrasonographic guidance can be tried safely when an ultrasonographic window is available which suggests the absence of intestinal loop interposition along the percutaneous tract (Matlaga et al., 2006; Desai and Symons, 2011).

In patients with a single kidney (congenital, functional, or surgical), PCNL must be performed with caution because the complications of this method, especially bleeding, have a major impact. In these situations it is recommended to preoperatively assess the renal function through isotopic imagistic tests. There are only several studies in the literature, conducted on a small number of patients with solitary kidney, who underwent PCNL without the occurrence of any complications (Mahboub and Shakibi, 2008).

Lithiasis on a transplanted kidney is a rare complication, with an incidence ranging from 0.2% to 1.7%, but may lead to a rapid deterioration of the renal function. The treatment of lithiasis in this category of patients is complex due to immunosuppression, a borderline renal function, and the nonspecific clinical picture which raises diagnostic issues. Typical renal colic does not appear in patients with transplanted kidney due to the denervated ureter, the clinical picture induced by lithiasic obstruction frequently being attributed to organ rejection or acute tubular necrosis.

The symptoms most frequently encountered are fever of unspecified etiology, increase in serum creatinine levels, oliguria or anuria, and hematuria. The occurrence of these symptoms requires imagistic explorations to detect any potential stones. The localization of the transplanted kidney can be difficult due to the superposition of the pelvic bones. Percutaneous approach is recommended at the level of an upper calyx oriented anteriorly, with the patient in supine position. Preoperative CT exam is mandatory in order to exclude potential superposition of intestinal loops and to plan the optimal percutaneous tract. Also, it should be taken into account that the tract's dilation can be hindered by perirenal fibrosis (Rifaioglu et al., 2008).

3.3 PREOPERATIVE PREPARATION

3.3.1 Prophylactic Antibiotic Treatment

Urinary tract infection represents a contraindication for PCNL and for this reason all urinary infections detected before the intervention must be treated according to the antibiogram. Significant preoperative bacteriuria was detected in approximately 36% of patients undergoing PCNL (Rao et al., 1991). The same study shows a statistically significant association between the presence of preoperative bacteriuria and the occurrence of postoperative bacteremia (bacteremia in 37% of patients with positive uroculture compared to only 8% in those with preoperative sterile urine).

Even in patients with preoperative sterile urocultures it is recommended to administer a fluoroquinolone or a cephalosporin 24 h before the intervention, despite the fact that there are no randomized clinical trials supporting the need for antibiotic prophylaxis in this category of patients. Thus, Charton and coworkers performed PCNL in a series of 107 patients with preoperative sterile urocultures, in whom prophylactic antibiotic therapy was not administered, 35% of them presenting urinary infections post-PCNL (Charton, 1986). In a prospective randomized study, Inglis and Tolley showed that prophylactic antibiotic treatment reduced the incidence of postoperative urinary infections in patients with preoperative sterile urine who underwent PCNL (2% compared to 12%) (Etemadian et al., 2008). This attitude is also supported by the fact that renal lithiasis itself represents a source of infection, and postoperative fever has also been described in patients with preoperative negative uroculture. Between 14% and 35% of renal stones extracted through PCNL contain germs (Hargreave and Ghosh, 1999). There is evidence that preoperative prophylaxis for 1 week with an oral fluoroquinolone reduces the risk of post-PCNL sepsis, regardless of the result of the preoperative uroculture (Desai and Symons, 2011). Moreover, even in cases with positive uroculture, the germ identified before the intervention may differ from the one found in the stone. For this reason, a uroculture taken during the intervention can be extremely useful in choosing the postoperative antibiotic therapy (Türk et al., 2012; Desai and Symons, 2011). In patients who present intra- or postoperative fever, antibiotic therapy must be continued until the fever disappears or until the nephrostomy tube is removed (Ng et al., 2006).

There are also situations in which pyuric urine is aspirated when puncturing the pyelocaliceal system in patients with sterile urine, without fever, and who received prophylactic antibiotic therapy. In such cases it is recommended to place a nephrostomy tube and to delay the intervention until the urine becomes clear and sterile (Etemadian et al., 2008). Usually, after approximately 7 days of antibiotic treatment, the uroculture from the urine sampled both from the urinary bladder and from the nephrostomy tube is sterile, and PCNL (Fig. 3.17) can be performed without the risk of sepsis (Meretyk et al., 1992).

3.3.2 Irrigation Fluid

While preparing the intervention, the fact that there is a risk of absorption and leakage of the irrigation fluid during PCNL should be taken into account. The rapid systemic absorption of the irrigation fluid through the veins injured while creating the tract or through peritoneal resorption (after accidentally injuring the peritoneum) may lead to postnephrolithotomy syndrome. This syndrome, somewhat similar to the one that occurs after the absorption of irrigation fluid during transurethral prostatic resection (post-TURP syndrome), has been described especially when 1.5% glycine solution was used as an irrigation fluid. There are only several studies in the literature that describe the occurrence of hemodilution and hyponatremia after PCNL (Cariou et al., 1985; Lauritz, 1986; Chou et al., 2003; Feizzadeh et al., 2006). The effects produced by the absorption of the irrigation fluid are clinically insignificant for most patients, but they can have important consequences in patients with impaired renal or cardiovascular function, as well as in children (Ng et al., 2006).

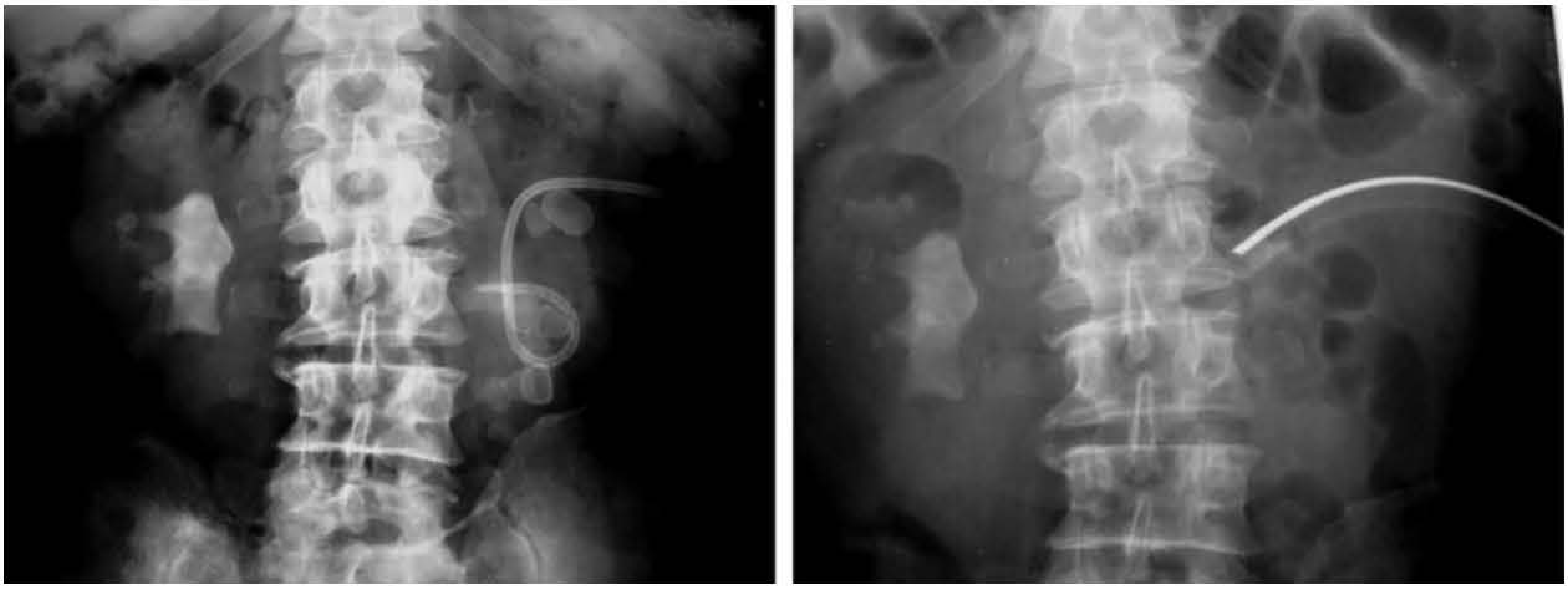


FIGURE 3.17 **Right renal lithiasis and infected multiple left renal lithiasis for which a nephrostomy is performed, followed by left PCNL.**

This syndrome is diagnosed with difficulty and frequently late, especially when the intervention is carried out under general anesthesia. Frequently, there is an unexplainable increase, followed by a crash of the arterial tension, refractory bradycardia, and ECG anomalies (Fellahi et al., 1992; Aghamir et al., 2009).

The adequate choice of the irrigation fluid can prevent this syndrome from occurring. The ideal irrigation solution should be isotonic, nontoxic, nonhemolytic, transparent (for an adequate visibility), easy to sterilize, and inexpensive. No such solution exists in practice. However, saline solution and Ringer lactate solution are the closest to reaching these desiderates, their absorption producing the least complications. Sterile water meets many of these conditions, but presents the disadvantage of a high hypotonicity and the risk of triggering renal failure or shock (Aghamir et al., 2009). Absorption of the irrigation fluid can also be associated with fever (infectious or noninfectious), which requires an adequate preoperative assessment of the presence of urinary infection. Regardless of the irrigation fluid which was chosen, this must be used at a temperature as close as possible to human body temperature, to prevent the occurrence of hypothermia (Ng et al., 2006).

3.4 ANESTHESIA

In most cases, PCNL is performed in prone position under regional (spinal/epidural) or general anesthesia. Practically, any anesthetic method can be used in selected cases. The successful achievement of this intervention using all types of anesthesia (local, paravertebral block, or epidural/spinal combined anesthesia) is currently described. Choosing the adequate anesthetic method for a certain surgical procedure depends on several factors such as the patient's physiological status, associated comorbidities, specific surgical reasons, intra- and postoperative control of pain, and last but not least, physicians' (surgeon and anesthesiologist) and patient's preference. There are cases in which, although a certain type of anesthesia is theoretically and technically possible, the aspects related to the patient's safety and comfort may contraindicate that particular anesthetic method. From this point of view, cooperation between the surgeon and the anesthesiologist is essential for the optimal planning of the intervention.

Performing PCNL under spinal anesthesia with a low dose of bupivacaine was first described by Atallah et al. (2006). Spinal anesthesia is a regional anesthesia that consists of intrathecal injection into the cerebrospinal fluid, at the lumbar level, of the anesthetic agent, obtaining a sensory, motor, and sympathetic blockade. The most frequently used agents are bupivacaine, prilocaine, and lignocaine, the choice of the anesthetic agent depending on how quickly the effect starts and on the duration of action. Diffusion (ascent) of the anesthetic agent may be influenced by modifying the patient's position. This type of anesthesia has the advantages of a quick debut, hemodynamic stability, good efficacy regarding intra- and postoperative analgesia, a good comfort of the patient and surgeon, and an estimated duration of approximately 60–90 min, which can be prolonged by using epinephrine (adrenaline). The rate of failure described in the literature for spinal anesthesia is 5–10%, these cases requiring repeating the procedure, adding an intravenous anesthetic agent, or conversion to another type of anesthesia (general) (Cousins et al., 2005). Compared to general anesthesia, spinal anesthesia has the advantage of a better control at the level of the abdomen and extremities and avoids the risk of anaphylaxis secondary to the administration of multiple substances. Moreover, the complications associated with general anesthesia, such as pulmonary (atelectasis), vascular, and neurological ones (due to injuries of the vertebrae or the nervous branches while changing the patient's position), are not as frequent (Mehrabi and Shirazi, 2010). Regarding the impact of spinal anesthesia on the most important intra- and postoperative parameters during PCNL, several studies have underlined a reduced intraoperative bleeding compared to general anesthesia. Other randomized clinical trials have demonstrated that regional anesthesia also associates a low risk of postoperative death and of severe complications (Rodgers et al., 2000).

Epidural anesthesia is a type of regional anesthesia that consists of injecting a local anesthetic (with or without opioid) into the epidural space, through a catheter placed at this level. The advantage, compared to spinal anesthesia, consists of the possibility of continuous administration or easy supplementation of the anesthetic, as well as the possibility of using it after the intervention. The combination of spinal and epidural anesthesia for PCNL has been used with the aim of reducing or eliminating the disadvantages of the two methods taken separately while maintaining their advantages, especially the possibility of epidural supplementation when spinal anesthesia becomes inefficient during prolonged interventions. The incidence of some complications, such as hypotension or bradycardia, is similar to that seen in general anesthesia, but the control of postoperative pain is better and the convalescence period is shorter (Karacalar et al., 2009).

The paravertebral block (PVB) consists of injecting the anesthetic agent into the paravertebral space, ensuring a unilateral somatic and sympathetic blockade. PVB has recently emerged as a technical alternative to regional anesthesia for PCNL that provides an increased analgesic efficacy with a low rate of secondary effects and complications, applicable especially in patients in whom epidural or spinal anesthesia are contraindicated. PVB has been successfully used in a variety of other surgical procedures for obtaining a unilateral anesthesia and a satisfactory postoperative analgesia, as well as preoperative analgesia in patients with ureteral stones (Jamieson and Mariano, 2007). Klein and coworkers suggest that PVB provides a prolonged analgesia with lower secondary effects and consider that this anesthetic method produces an analgesia equivalent to local, direct, tissular infiltration of the anesthetic (Klein et al., 2000, 2002). Lumbar paravertebral anesthetic block with 0.5% bupivacaine confers a higher intraoperative hemodynamic stability, a prolonged analgesia, and an increased postoperative comfort for the patient, compared to epidural and general anesthesia in patients undergoing PCNL, without increasing the incidence of certain secondary effects such as nausea and vomiting (Elbealy et al., 2008).

The absolute contraindications for regional anesthesia are represented by refusal of the patient, coagulation disorders, septicemia, the presence of a local infection at the injection site, or of an allergy to the anesthetic agent, while the relative contraindications are increased intracranial pressure, chronic spinal disorders or diseases of the central nervous system, hypovolemia, and treatment with nonsteroidal anti-inflammatory drugs or heparinic derivatives (Robinson and Hall, 2002). A major advantage of regional anesthesia consists of the fact that a conscious patient allows for the quick evaluation of neurological changes and of respiratory function disorders (Cousins et al., 2005).

General anesthesia with endotracheal intubation (GA-EI) and intermittent positive pressure ventilation represents the preferred anesthetic technique in patients at risk, when laborious interventions or significant blood loss are expected or in patients with cardiovascular instability. General anesthesia increases the surgeon's operatory comfort and reduces the risk of complications such as bleeding or injury of the adjacent organs. Together with spinal anesthesia, it represents the most frequently used anesthetic method for performing PCNL. GA-EI implies maintaining an adequate analgesia, continuous monitoring of cardiorespiratory and biochemical parameters, a quick management of any complication that may occur during the surgical intervention, and continuing the care in the postoperative period (Cousins et al., 2005).

In recent years, in an attempt to minimize or avoid the classic technical complications, several variants of anesthesia for PCNL have been described. Wu and coworkers described an intubation technique while maintaining consciousness (awake intubation), which allows the patient to position himself in the prone position at the beginning of PCNL. This technique has been described as safe, efficient, and useful in selected cases and especially in obese patients (Wu et al., 2009). Aravantinos et al. (2009) used a multimodal anesthesia for PCNL that includes paracetamol, cyclooxygenase 2 inhibitors, morphine administered epidurally, and infiltration of the tract with local anesthetics. PCNL with local anesthesia has also been reported recently in the literature in selected cases. This is a natural consequence of the evolution of techniques and instruments for PCNL (miniperc, tubeless), as well as the efforts for reducing the procedure's morbidity, the amount of anesthetic necessary, and the duration of hospitalization. The main reason for performing PCNL under local anesthesia consists especially of the presence of severe associated comorbidities that contraindicate the other anesthetic techniques. Another argument is represented by the recent hypothesis that pain during PCNL is due to dilation of the parenchyma and especially of the renal capsule and is not due to intrarenal manipulation of the stone. Therefore, the renal capsule represents the place where the anesthetic should be administered. Preminger et al. (1986) described performing PCNL on an outpatient basis in a series of 5 patients with small renal calculi under local anesthesia, while, more recently, Dalela et al. (2004) used infiltration of the anesthetic (lignocaine) at the level of the renal puncture site to determine a renal capsular block, thus allowing successful performance of PCNL in a series of 11 patients. However, the most important series of PCNL with local anesthesia was reported by Aravantinos in 2007 in patients with unilateral renal obstruction due to pyelic stones larger than 2 cm and in whom 16 Ch percutaneous nephrostomy with local anesthesia for decompression was performed 1 week before the definitive intervention. Nephrostomy was performed after infiltration with lignocaine of the renal parenchyma and the tract, while PCNL was carried out using a 24 F rigid nephroscope and ballistic lithotripsy. All patients received intramuscular pethidine within 30 min before each step and oral diazepam (0.1 mg/kg) before PCNL. The authors concluded that PCNL with local anesthesia represents a feasible and safe technique in selected patients (patients who can cooperate with the surgeon, with renal lithiasis of optimal dimensions, and pyelocaliceal system dilation that facilitates percutaneous nephrostomy). The reported success rate was 85%, and no major complications associated with the procedure or complications related to the local anesthetic were described. While interpreting these data, it should be taken into account that patients with staghorn or voluminous calculi were excluded, as well as those with previous renal surgical interventions, situations that require an increased duration of the intervention or creating multiple tracts (Aravantinos et al., 2007).

3.5 PATIENT POSITIONING

The correct access to the renal cavities during percutaneous nephrolithotomy is facilitated by a careful positioning of the patient on the operating table.

Traditionally, PCNL was performed with the patient in prone position. This position provides an optimal access to the collecting system, which theoretically allows the puncture of a calyx in the avascular area of the renal parenchyma, without determining significant bleeding, peritoneal perforation, or visceral injuries. In fact, the fear of injuring the intra-abdominal organs, especially the colon, probably determined the prone positioning of patients when the percutaneous nephrostomy technique was first described (Goodwin et al., 1955) and subsequently when PCNL became popular in the urological community.

With the understanding of renal anatomy and visceral relations, numerous changes of patient positioning have been described in the following:

- prone-flexed position
- oblique prone position
- supine position
- oblique supine position
- lateral decubitus

3.5.1 Nephrolithotomy With the Patient in Prone Position

The prone position (Fig. 3.18) was adopted because it ensures a wide field for puncturing the kidney, without limiting the movements of the instruments and allowing for a simple execution of multiple tracts.

The physiological lumbar lordosis is more pronounced in the prone position, determining a narrowing of the working field. The patient's flexion (Fig. 3.19) on the operating table increases the distance between the XII-th rib and the iliac crest, increasing the space through which the adequate puncture of the kidney can be achieved. Also, the approach of the upper calyx is relatively easy, the position allowing the downward access of the nephroscope toward the renal pelvis with minimal tension, the mobile lower pole aligning with the nephroscope's axis. This type of approach is preferred in obese patients, the upper pole being closer to the posterior abdominal wall (Ray and Honey, 2012).

From a practical point of view, the intervention begins with the patient in the lithotomy position for the retrograde ascent of a ureteral catheter into the pyelocaliceal system. If the patient is placed in the prone position with the lower limbs in abduction (Fig. 3.20), there is the possibility of a simultaneous antegrade and retrograde approach. Identification of the ureteral orifices in the prone position may be more difficult for surgeons who are unfamiliar with this technique. Sometimes, in the case of urinary tract obstruction, objectification of the posterior caliceal groups may be difficult, the urine not allowing the contrast medium to enter these calices located superiorly.

The puncture of the upper calyces is easier in this position than in the case of interventions performed in supine position.

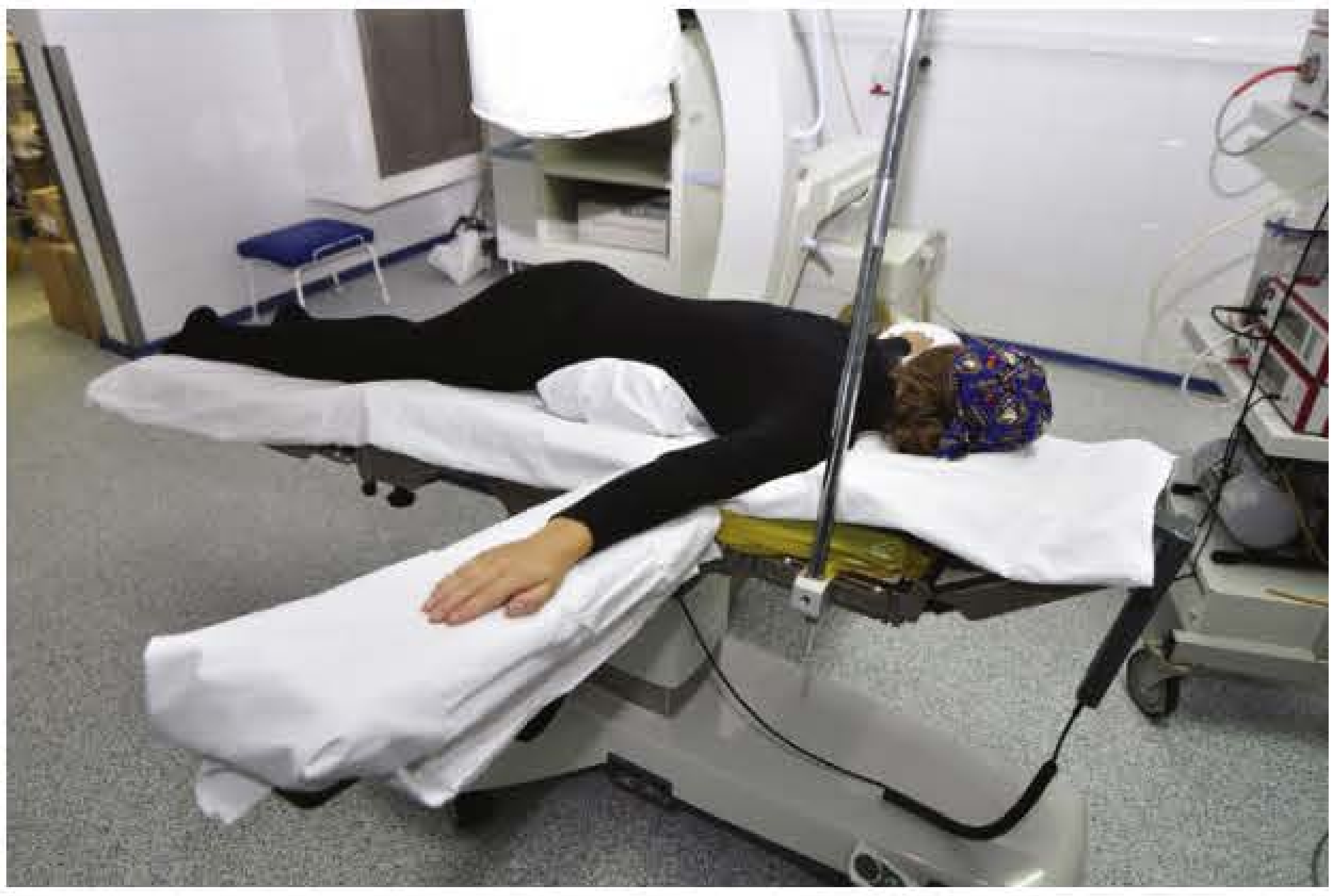


FIGURE 3.18 **Prone position of the patient.**

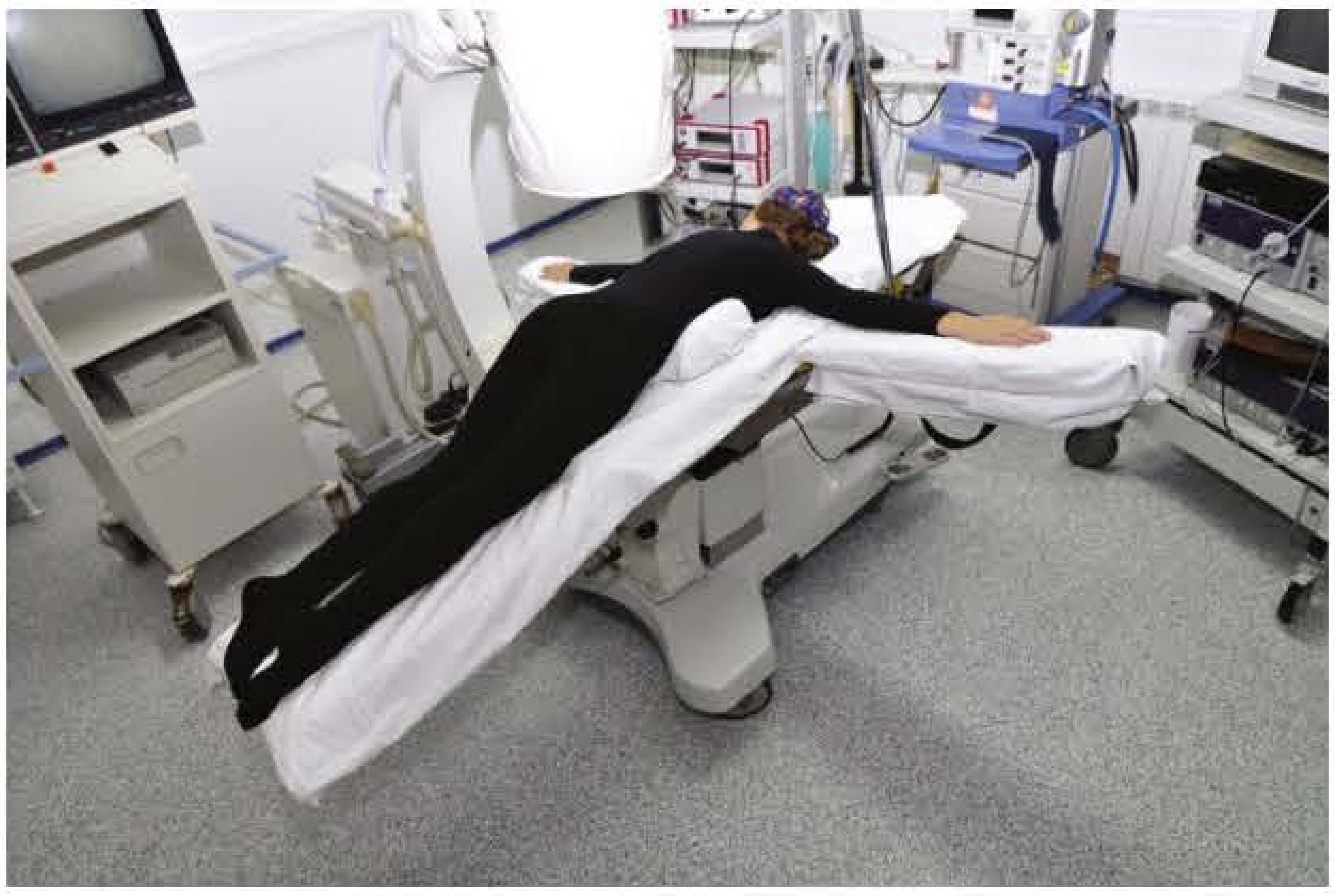


FIGURE 3.19 **Placing the patient in prone-flexed position.**

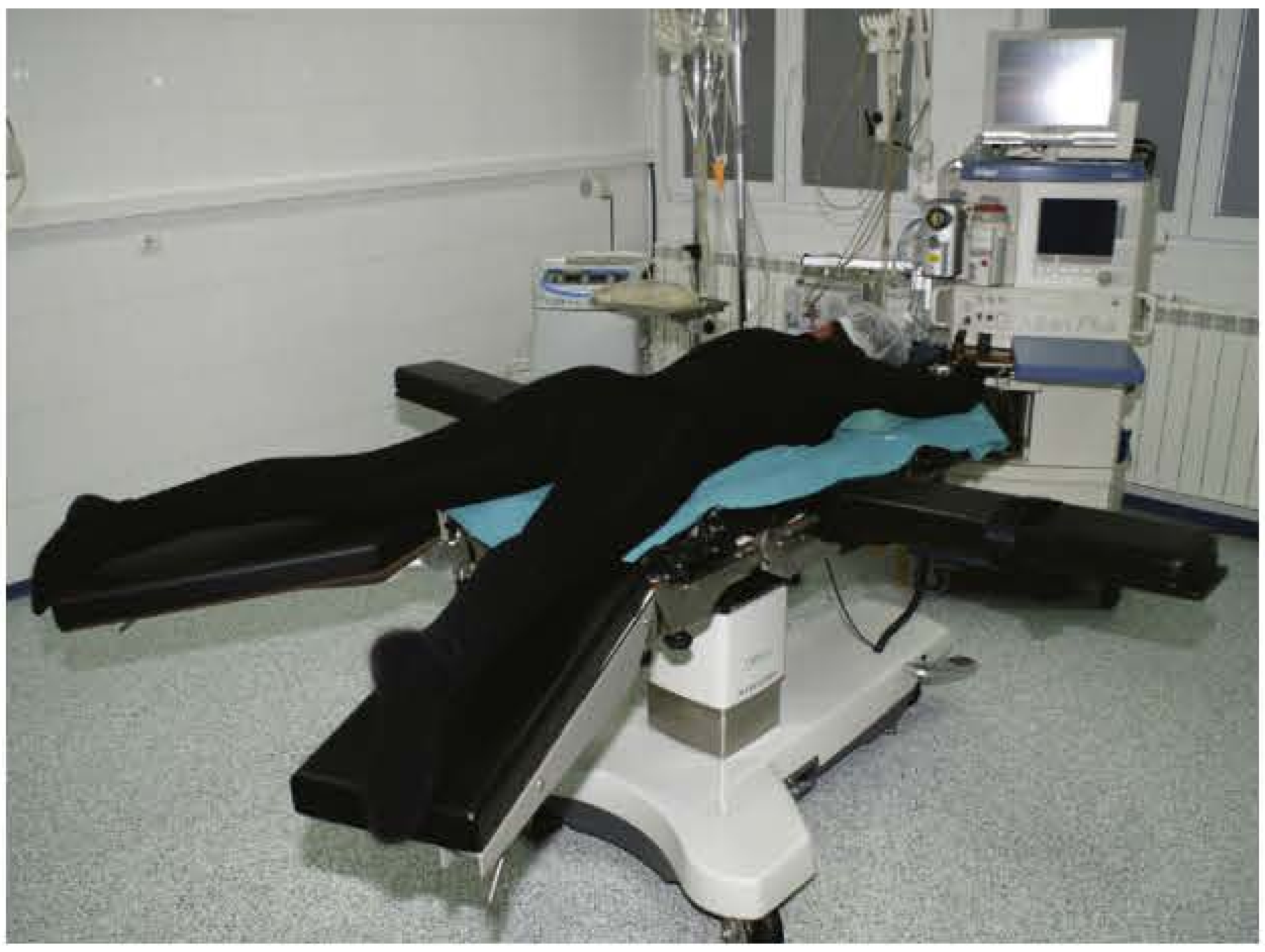


FIGURE 3.20 **Placing the patient in prone position with the lower limbs in abduction.**

Modifying this position by flexion of the patient on the table by 30–40 degree also determines a downward displacement of the kidney, therefore also modifying the puncture site (e.g., a puncture that in classic prone position is performed in the XI-th space will be performed in the XII-th space after this modification) (Ray and Honey, 2012).

However, performing PCNL in prone position also has some disadvantages. It is associated with a restriction in the patient's respiratory movements and in consequence is not always possible. Morbid obesity and compromised cardiorespiratory status also provide challenges, both for the anesthesiologist and for the surgeon (Ray and Honey, 2012). Placing the patient in prone position may also be difficult in the case of patients with contractures of the lower limbs.

Moreover, general anesthesia and ureteral catheterism are usually performed with the patient placed in the lithotomy position, and only subsequently the patient is turned over in prone position for the percutaneous approach, these maneuvers increasing the intervention's duration.

Also, the prone percutaneous approach does not completely eliminate the risk of complications. Studies conducted in large groups of patients have demonstrated a rate of 3–10% of acute bleeding that requires transfusions and an incidence of 0.5% of colon perforations (LeRoy et al., 1985; Segura et al., 1985; Jones et al., 1990). In the case of complex lithiasis, the success rates of prone PCNL vary between 74% and 83%, while the rate of transfusions ranges between 14% and 24% (Preminger et al., 2005).

In an attempt to improve the results and to overcome these limitations, with the increase in experience the high number of combined procedures has led to the modification of the prone PCNL technique. Thus, relatively recent studies using modern imagistic methods have demonstrated the safety of placing a lateral percutaneous nephrostomy (Krasny and Deseran, 1997; Boon et al., 2001; Prassopoulos et al., 1990).

3.5.2 Percutaneous Nephrolithotomy With the Patient in Supine Position

Performing percutaneous nephrolithotomy in supine position was first described in 1998 by Valdivia Uria et al. (1998) who stated that this intervention offers benefits especially in patients with a high anesthetic risk. Valdivia Uria proposed positioning the patient in supine position and placing a 3-L bag of fluid beneath the ipsilateral flank with the ipsilateral leg completely extended (Fig. 3.21). Other authors consider that a smaller pillow frequently proved to be more efficient, allowing to raise the body by 15–20 degree (De Sio et al., 2008). Ng et al. (2004) observed, in a group of Asian patients with a leaner constitution than Caucasians, that a 500- or 1000-mL bag of fluid is sufficient.

Excessive raising of the ipsilateral lumbar area determines the kidney's tendency to become more medial, thus increasing the length of the nephrostomy tract.

It is recommended to position the patient's flank and the bag of saline at the edge of the operating table, so that the maneuverability of the instruments is not limited during the intervention (Valdivia Uria, 2012). Also, it is not recommended to use nephroscopes with a reduced length.

By performing renal punctures in cadavers, Valdivia Uria did not observe any kind of lesions of the peritoneum or colon. CT evaluation confirmed the fact that in supine position, the colon is farther away from the kidney compared to prone position.

Thus, it was suggested that the anterior displacement of the colon in supine position compared to prone position determines a reduction in the risk of colon injury.

LeRoy et al. (1985) and Hopper et al. (1987) observed that only 2% of patients had a retrorenal colon in supine position, a percentage that increased to 10% in prone position.

Positioning the patient in supine position does not require changing the position after placing the ureteral catheter, as in the case of the prone position. The supine position is much more comfortable for the patient and requires a lower dose of anesthetics. Also, this position allows an easier access to the respiratory tract and therefore can be less dangerous, especially in patients with impaired cardiopulmonary function or morbid obesity or in those who require a prolonged duration of the intervention.

The initial description, in a group of 557 patients (Valdivia Uria et al., 1998), showed a success rate of 93% for the procedure, with a low incidence of complications and without colon perforations. Valdivia Uria also demonstrated the feasibility of this technique in the case of kidneys with malformations, of horseshoe kidneys, or in cases which required multiple tracts. The supine PCNL technique was further improved by Ibarluzea et al. (2007), opening the era of intrarenal surgery by combined approach (Ibarluzea et al., 2007; De Sio et al., 2008; Manohar et al., 2007; Ng et al., 2004; Scoffone et al., 2008; Shoma et al., 2002; Steele and Marshall, 2007). The advantages of this technique are well documented including an easier management of anesthesia, the absence of patient repositioning, as well as the possibility for simultaneous antegrade and retrograde approach (Fig. 3.22).

If a combined approach is required, Valvidia Uria recommends flexing the lower limbs, with the contralateral leg lowered to facilitate the maneuvering of the ureteroscope (Fig. 3.23).

In the Galdakao-modified Valdivia position (Fig. 3.24), the patient is placed in supine position with the ipsilateral lower leg in extension and the other in flexion. This position also allows retrograde access to the upper urinary tract. The ipsilateral arm is crossed over the chest. The ipsilateral lumbar area is raised by 20 degree with the aid of an

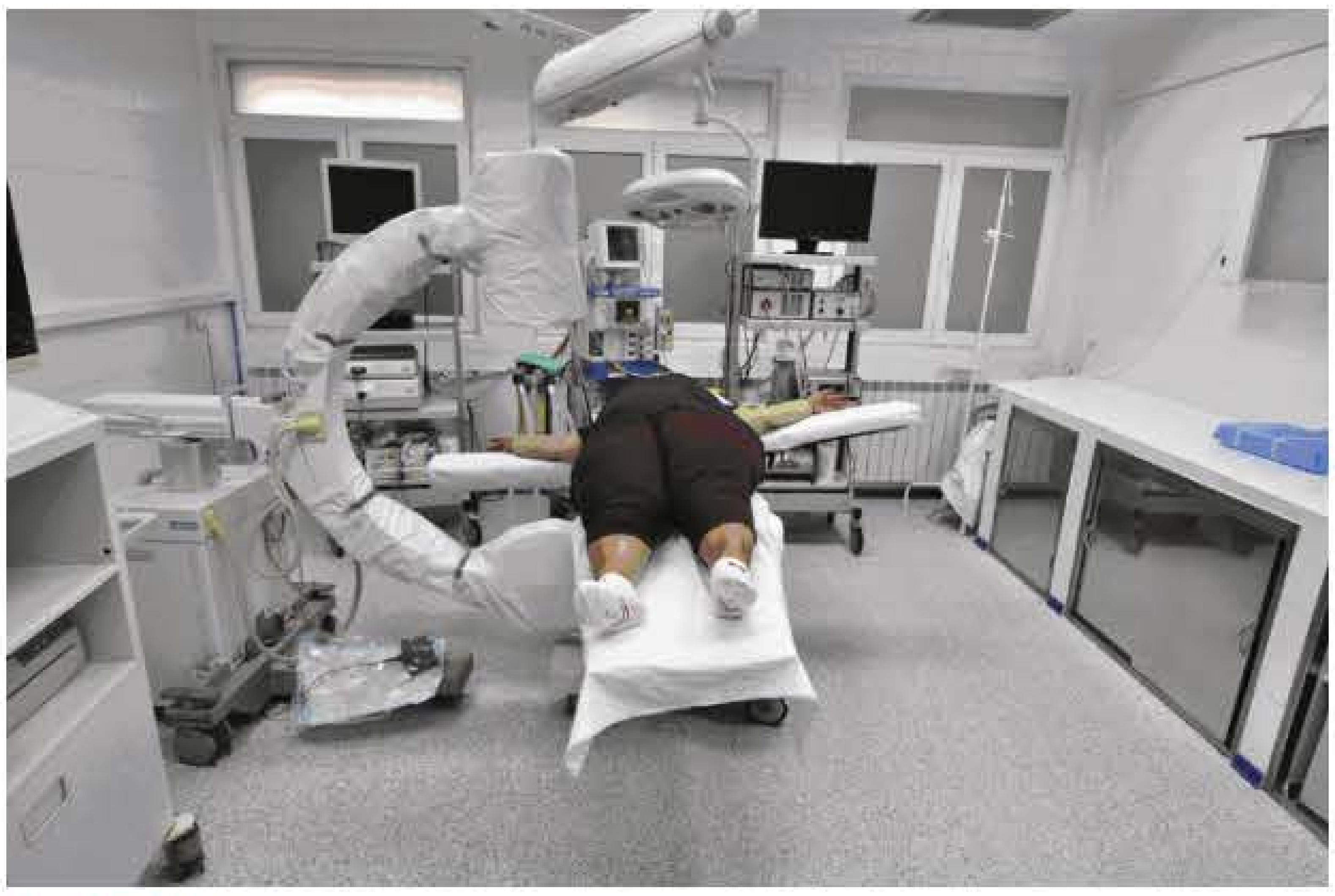


FIGURE 3.21 **Placing the patient in supine position (the Valdivia position).**

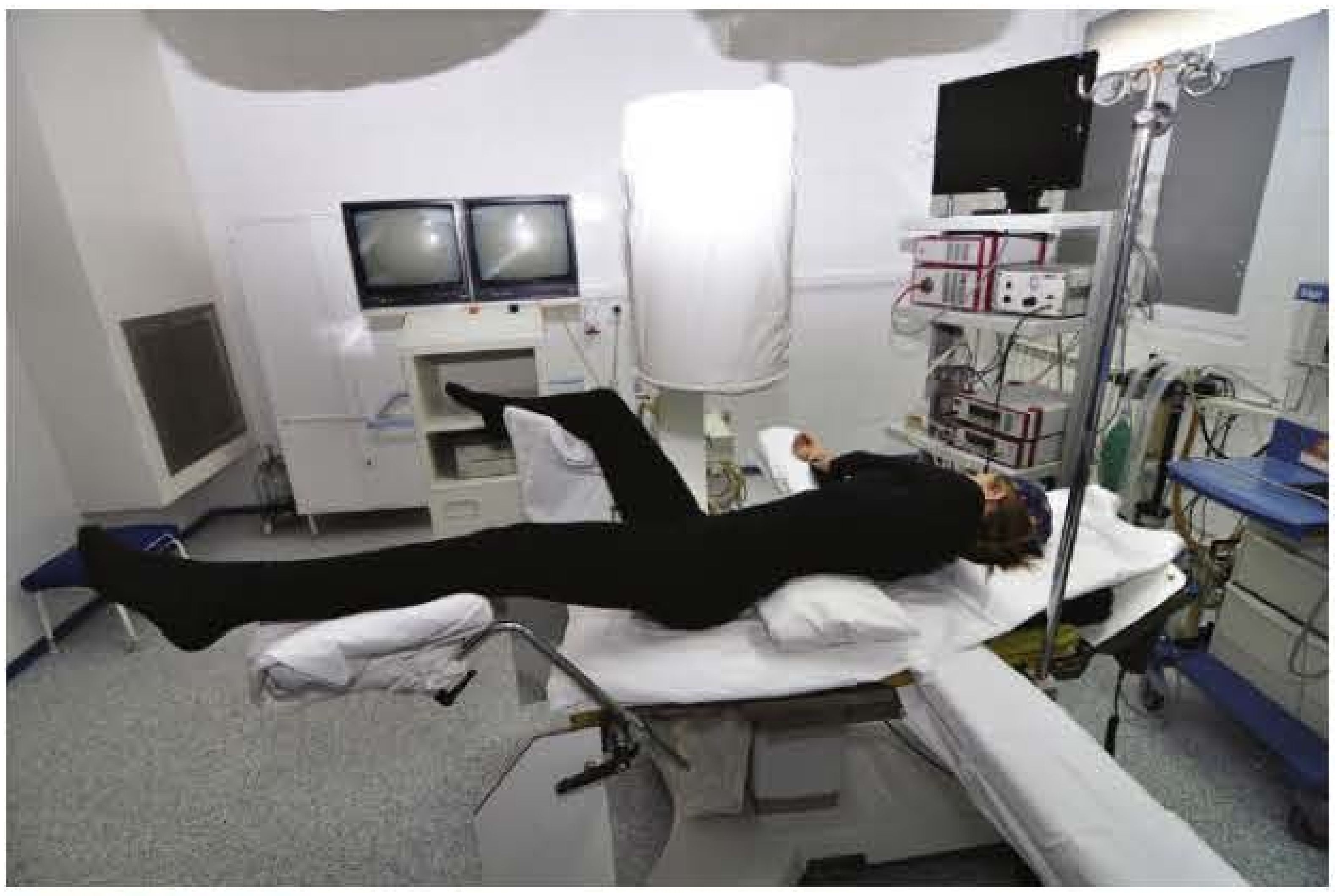


FIGURE 3.22 **Positioning the patient for combined approach.**

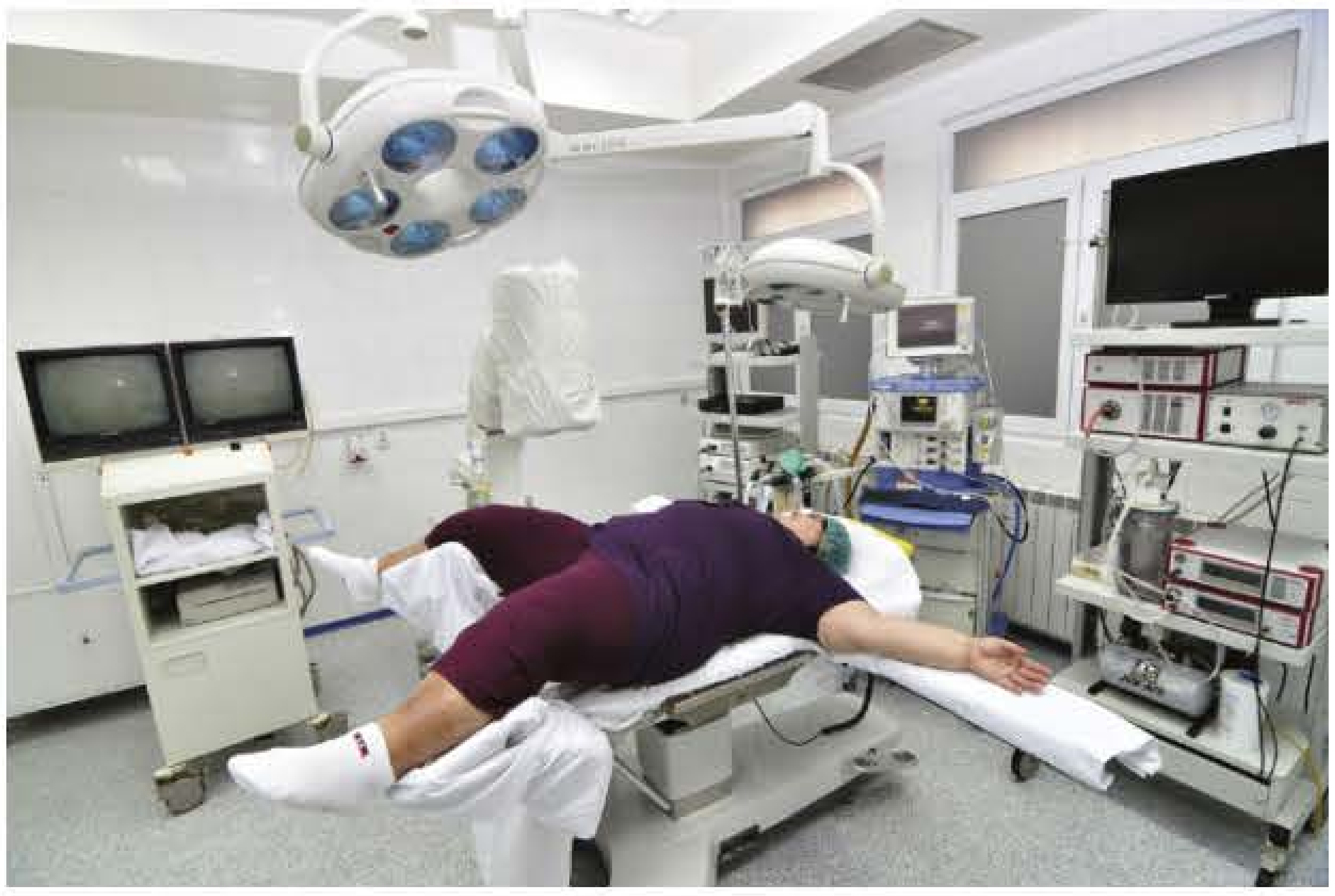


FIGURE 3.23 The Valdivia Uria position for combined approach.

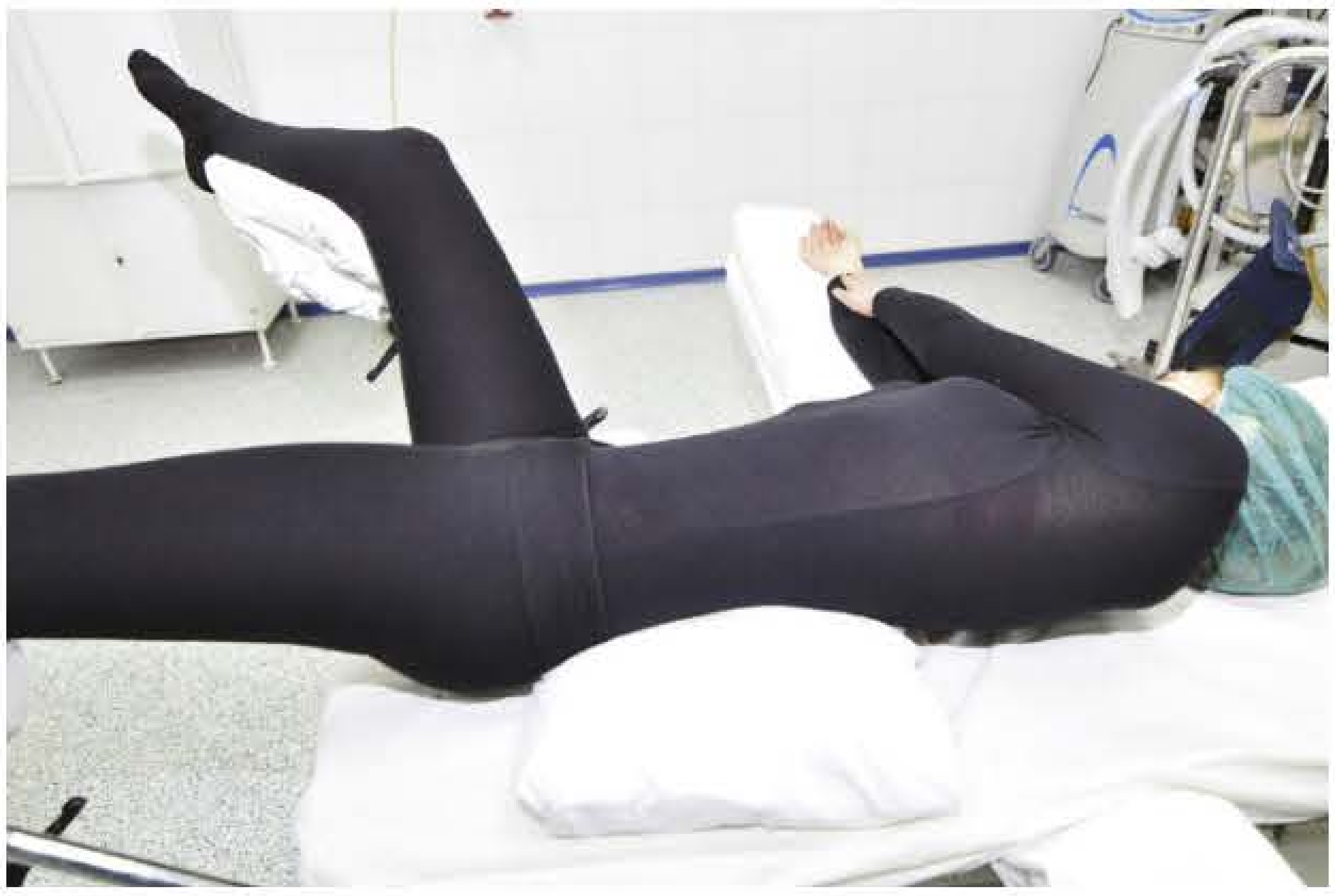


FIGURE 3.24 The Galdakao-modified Valdivia position.

inflatable device (Pelvic-Tilt, Confort, Glen Ridge, NJ, USA) (Hoznek et al., 2012). This device presents, on one of its sides, an extension which is positioned under the contralateral lumbar region. The weight of the patient exerted on this extension prevents the lateral displacement of the patient.

Another variant is represented by the pure supine position (Fig. 3.25), without the lumbar support described by Valdivia Uria (Falahatkar et al., 2008).

Another variant is represented by performing PCNL in oblique supine position (Fig. 3.26). Compared to the classic supine position, this has the advantage of facilitating an accurate and safe puncture under ultrasonographic guidance (Arrabal-Martin, 2012). Those who support the oblique supine position consider that an easier access can be obtained during PCNL (Desai and Symons, 2011; Ng et al., 2004). It must be mentioned that by placing the patient in the oblique supine position, the kidney's axis is modified compared to cases in which the patient is placed on a straight plane.

There are several variants described in the literature regarding the choice of the puncture site and the calyx approached in the case of supine percutaneous nephrolithotomy.

Valdivia Uria et al. (1998) and Neto et al. (2007) recommend performing the puncture on the posterior axillary line, while Ng et al. (2004) described creating the tract on the anterior axillary line.

3.5.2.1 Advantages

Several advantages have been mentioned for conducting a supine percutaneous approach: reduced cardiocirculatory and ventilatory dysfunctions, a better tolerance when the intervention is performed under regional or local anesthesia, and a reduced duration of the procedure because patients do not need to be turned over after the induction of general anesthesia and after placing the ureteral catheter (Valdivia Uria, 2012).

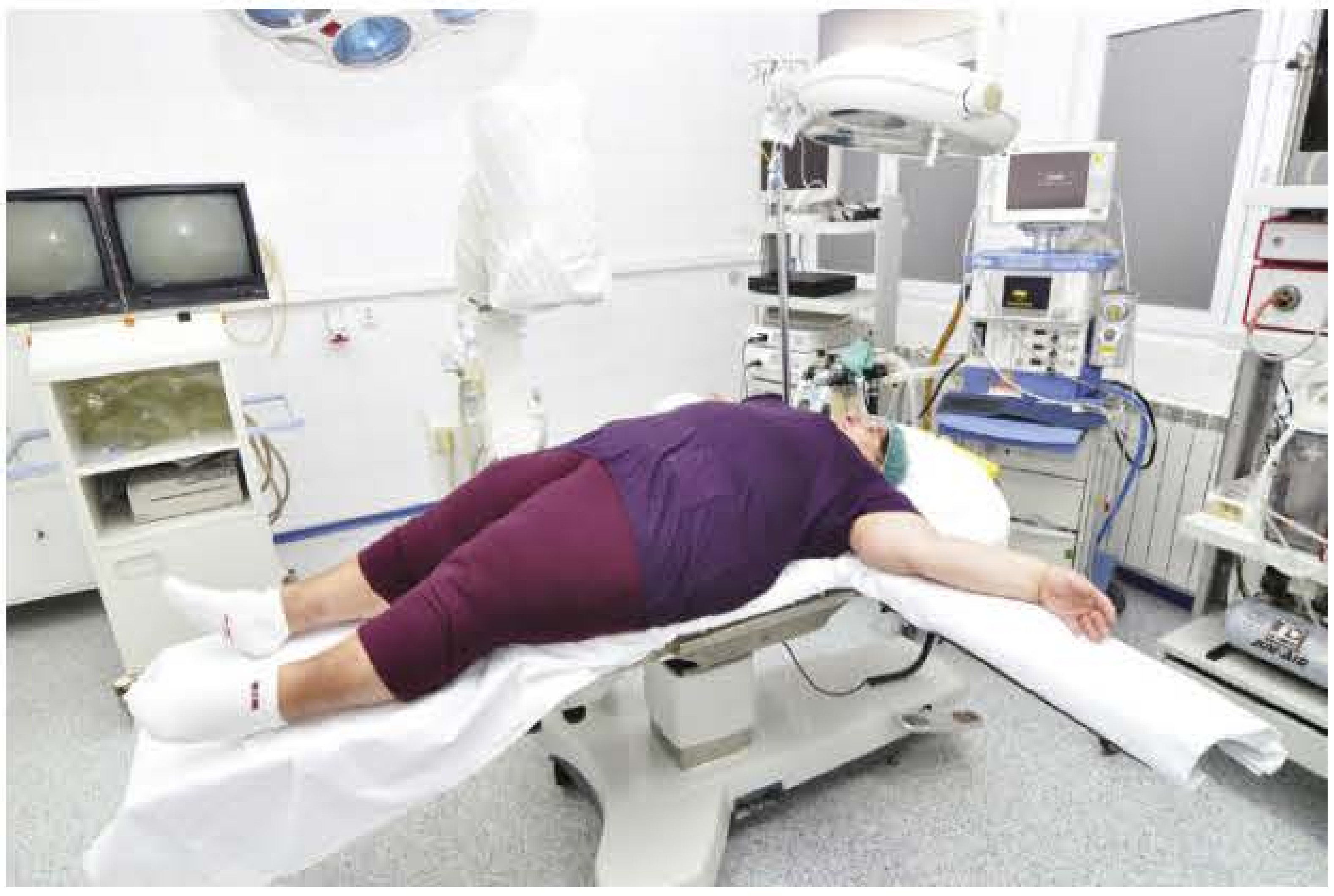


FIGURE 3.25 Supine position without lumbar support.

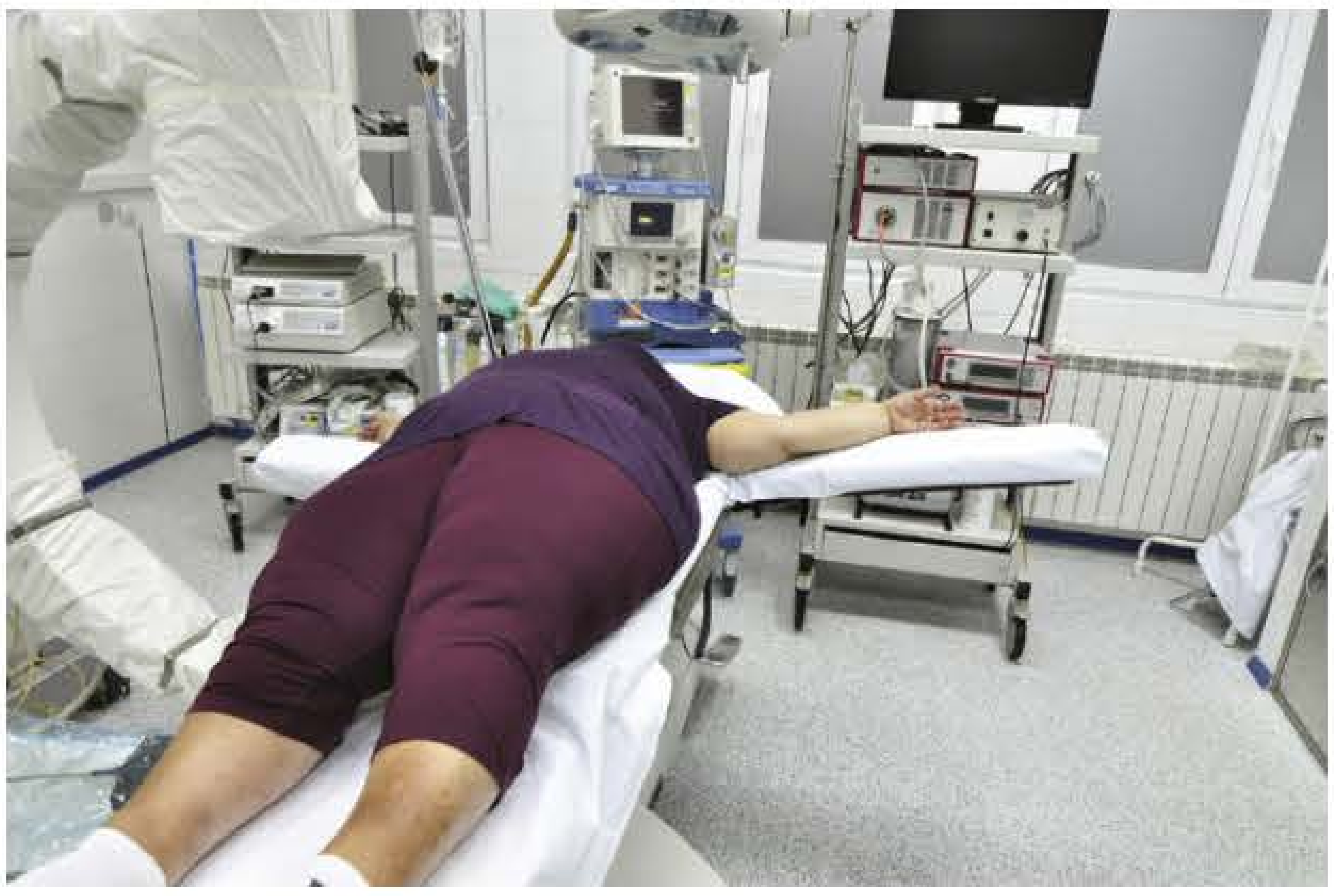


FIGURE 3.26 Oblique supine position.

Also, the supine position provides a viable alternative in patients with morbid obesity. In a group of 62 patients with morbid obesity, Manohar et al. (2007) obtained a stone-free rate of 95% after supine PCNL, with or without concomitant ureteroscopy, with a rate of transfusions of 3%.

A recently published comparative study regarding the results of prone or supine PCNL in a group of 48 obese patients showed similar results, the supine position presenting the advantage of a reduced duration of procedures and a shorter hospitalization (Mazzucchi et al., 2012).

Performing supine PCNL also allows for a more comfortable posture of the surgeon during the procedure, with a lower radiological exposure, the puncture and dilation of the nephrostomy tract being almost perpendicular to the patient's trunk, the surgeon's hands thus being outside the fluoroscopic field.

Also, this position facilitates performing the caliceal puncture. The X-rays are perpendicular on the direction of the puncture needle and of the caliceal axis, the displacement of the caliceal cup in the moment of the puncture being easier to evaluate, without requiring to move the arm of the fluoroscope.

The absorption of fluids during PCNL has a clinical significance in the case of patients with compromised cardiorespiratory or renal function (Kukreja et al., 2002). If the patient is placed in supine position, the Amplatz sheath is oriented downward, maintaining a low pressure in the renal pelvis and reducing the risk of fluid absorption, at the same time also facilitating the spontaneous evacuation of lithiasic fragments and limiting the dislocation of stones in the calyces or ureter. Unfortunately, this fact also leads to the collapse of the pyelocaliceal cavity with the consecutive reduction of the visual field.

Regarding the Amplatz sheath, it can be fixed to the skin with a suture thread in order to prevent its exit from the collecting system during the extraction of stones (Valdivia Uria, 2012).

Last but not least, by rotating the lower limbs in the lithotomy position, antegrade and retrograde procedures can be performed efficiently. This is the main advantage of the procedure because it combines the benefits of percutaneous and ureteroscopic intrarenal surgery. This approach provides advantages both for the patient and the surgeon, and can be a viable option in complex cases, regardless of patient's age or habitus. The use of flexible endoscopes contributes to a reduction in the exposure to radiation, in the risk of bleeding or post-PCNL renal lesions (Cracco and Scoffone, 2011).

3.5.2.2 Limitations

The limitations of supine PCNL derive from the difficulty of nephroscopy if the pyelocaliceal system is not distended. Additionally, the puncture of the upper calyx is more difficult because the upper pole is situated medially and posteriorly, being more difficult to approach when the patient is in supine position. In order to overcome this limitation, it is recommended to tilt the patients on the contralateral side.

Some authors do not recommend the supine position in the case of staghorn stones because the edges of the operating table may prevent the lateral movements of the nephroscope. On the other hand, in prone position, the body area available for the insertion of the trocar is wider, allowing multiple and easy access tracts and unlimited movements of the instruments (De Sio et al., 2008).

Another disadvantage is represented by the delay in opacification of the lower calyces, these being situated in a higher position compared to the upper ones. This deficiency can be overcome by placing the patient in anti-Trendelenburg position for several minutes.

In the case of a mobile kidney, creating the nephrostomy tract in supine position implies additional difficulties due to excessive renal mobility that can lead to twisting the guidewire which hinders the advancement of the dilators. In these situations, a Lunderquist guidewire can be used for stabilizing the kidney. This mobility is reduced in the case of prone position, the renal ensemble being fixed by the weight and rigidity of the posterior abdominal wall resting on the operating table. Favorable results were also obtained by the extra-abdominal compression described by Shoma et al. (2002).

Also, the nephroscope's deflection for approaching the anterior calyces can be prevented by the edge of the operating table. Therefore, in these situations it is recommended to perform the puncture directly in the anterior calyx.

Although the results obtained clearly demonstrate that PCNL cannot be performed only in prone position, many urologists remain skeptical about adopting the supine position (de la Rosette et al., 2008; Basiri and Mohammadi Sichani, 2009).

A recent report of the Clinical Research Office of the Society of Endourology showed that only 20% of percutaneous nephrolithotomies carried out each year are performed in supine position (Valdivia et al., 2011). In consequence, randomized, prospective, multicentric trials are necessary in order to determine the type of approach adapted to the particularities of each case. Moreover, in order to obtain viable data, standardization is necessary for recording the results and complications of different techniques.

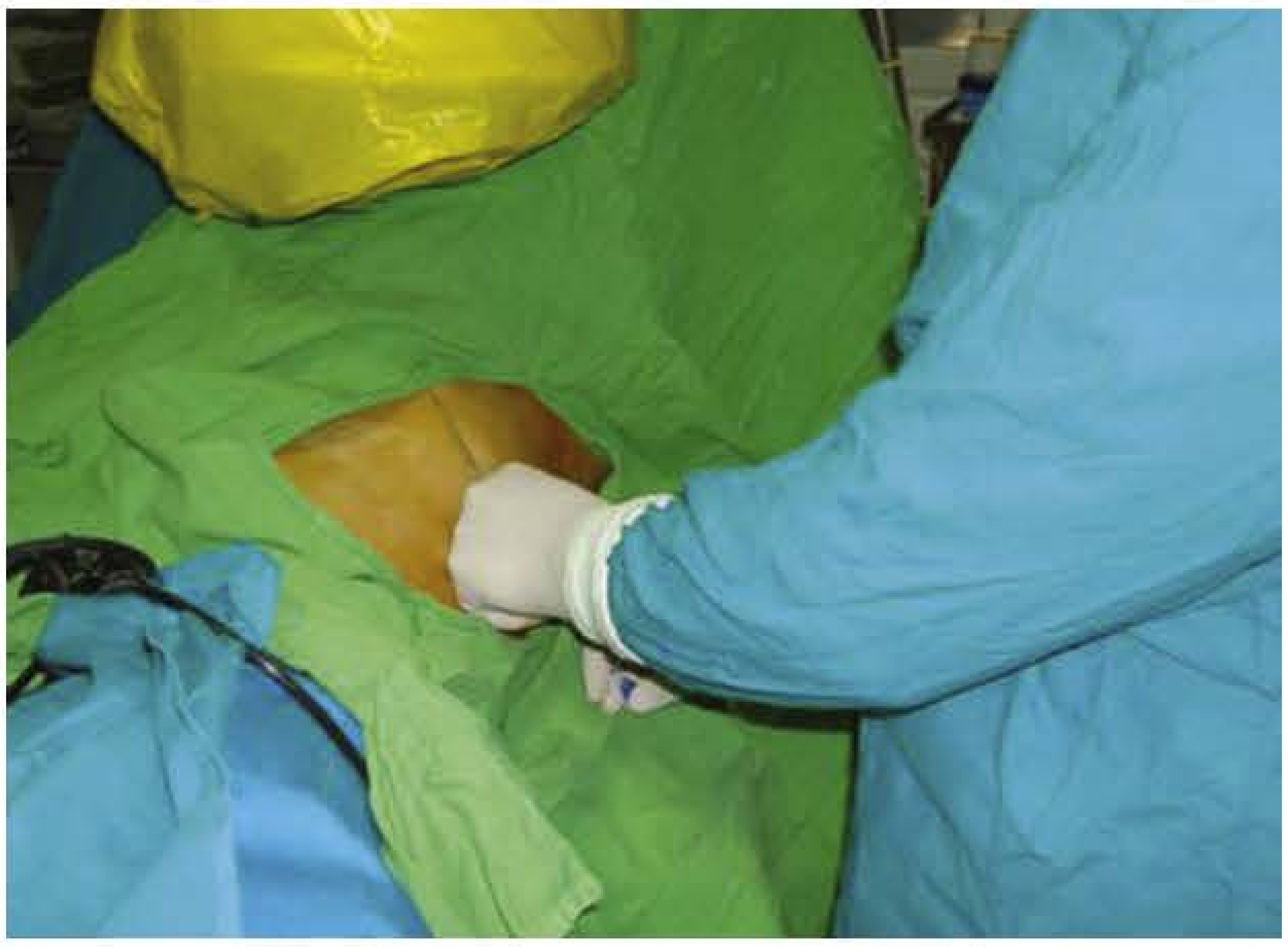


FIGURE 3.27 **Positioning the patient in lateral decubitus.**

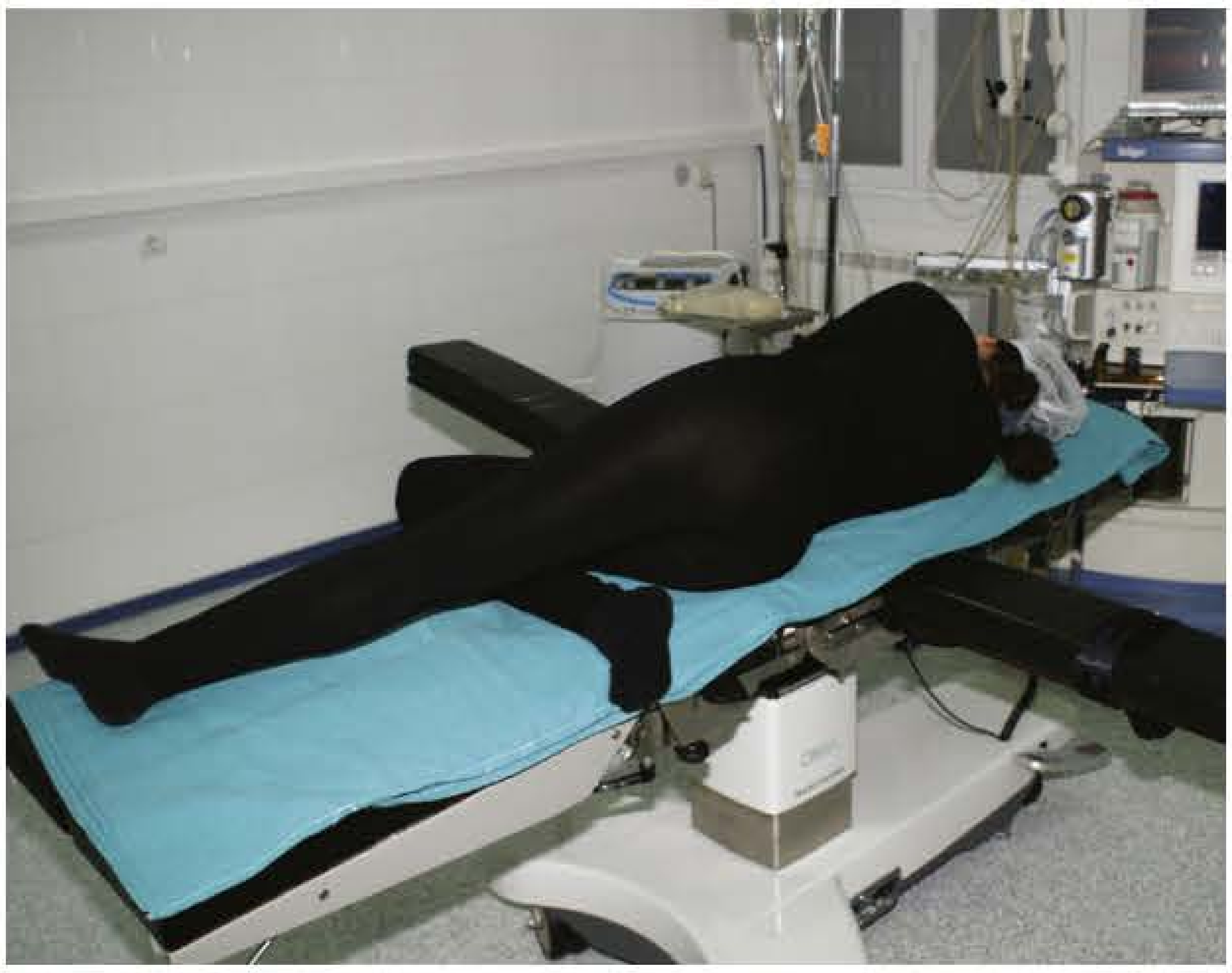


FIGURE 3.28 **Lateral flexion position.**

3.5.3 Percutaneous Nephrolithotomy With the Patient in Lateral Decubitus Position

Positioning the patient in lateral decubitus (Fig. 3.27) is recommended especially in patients with morbid obesity, sometimes this being the only position in which PCNL can be performed. In this position, the abdominal fat is situated laterally and does not exert pressure on the abdomen as in the case of supine position (Ray and Honey, 2012). Thus, the respiratory movements are facilitated, allowing to achieve general anesthesia in better conditions.

The lateral flexion position (Fig. 3.28) is similar to that in which open surgical lombotomy is performed. It allows for a wider operatory field, ensuring an optimal access to the upper calyx, due in part to the fact that there is less fatty tissue in the costo-vertebral angle (Ray and Honey, 2012).

The disadvantage of this position consists of the need for performing the puncture under ultrasonographic or fluoroscopic control, using the triangulation technique (Ray and Honey, 2012).

3.6 PYELOCALICEAL SYSTEM PUNCTURE

The puncture of the pyelocaliceal system represents the first and also the most important step of percutaneous nephrolithotomy. It is classically performed under fluoroscopic or ultrasonographic control, while other imagistic or endoscopic guidance modalities have also been recently introduced.

The purpose of the puncture is to achieve a percutaneous access tract to a posterior calyx, through a renal pyramid, approach which is associated with the lowest risk of complications (Thüroff and Gillitzer, 2008). The most frequent maneuver is represented by the puncture performed under fluoroscopic control, with the patient in prone position, on the posterior axillary line, between the XII-th rib and the iliac crest. There are many factors which may influence the choice of imagistic guidance modality and the puncture site (Thüroff and Gillitzer, 2008):

- patient's weight
- kidney's position
- particularities and/or anomalies of the bone structures
- positioning of the neighboring organs (colon, spleen, liver, lung) in relation with the kidney
- the puncture's target (type of calyx, caliceal diverticulum)

3.6.1 Choosing the Type of Control of the Puncture

3.6.1.1 Fluoroscopic Control

Fluoroscopy has been, and still is, the most frequently used modality for puncture guidance, requiring performing the intervention on a radiotransparent operating table. This is the elective method in case of percutaneous treatment of lithiasis in an undilated pyelocaliceal system, which makes ultrasonographic guidance more difficult (LeRoy, 2006).

The contrast medium is injected retrogradely through a preinserted ureteral catheter, achieving opacification and, at the same time, the distension of the pyelocaliceal system, thus facilitating the puncture.

This can also be injected intravenously, providing a pyelogram which can achieve an efficient guidance. There are, however, some limitations regarding the dose, due to the nephrotoxicity of the contrast medium, but also related to the impossibility of inducing an additional dilation. The contrast medium is injected intravenously when the ureteral catheter cannot be inserted retrogradely.

3.6.1.2 Ultrasonographic Control

The development of ultrasonography provided a guidance alternative for interventions on the urinary tract (LeRoy, 2006), with remarkable advantages: real-time visualization of the surrounding structures, the possibility of identifying the anterior and posterior calyces and, of course, the absence of irradiation both for the physician and the patient (Desai and Symons, 2011). Hydronephrosis facilitates the puncture guided in this way (Kumari-Subaiya and Phillips, 1995). Also, ultrasonographic transducers that have lumens or special guidance systems through which the needles can be inserted are available, thus increasing the accuracy of the puncture (Osman et al., 2005).

Ultrasonographic guidance in prone position can be compromised by artefacts generated by the ribs, but real-time monitoring and the transducer's angulation techniques overcome this inconvenience.

3.6.1.3 Combined Control

On the other hand, the combination between ultrasonographic and fluoroscopic guidance is frequently welcomed. Puncture under this combined guidance allows for a tridimensional visualization of the kidney and the pyelocaliceal system, with an easy identification of the surrounding organs (Wendt-Nordahl et al., 2011).

3.6.1.4 Other Types of Imagistic Control

Another guidance modality is represented by CT, which is addressed to certain extremely selected cases with splenomegaly, scoliosis, morbid obesity, and prior complex abdominal surgical interventions (LeRoy, 2006). Also, the approach under this guidance can also be very useful for percutaneous puncture in patients with ileal conducts or lithiasis associated with an angiomyolipoma with a high risk of bleeding (Eiley et al., 1999; Gupta et al., 2007).

There is also the opportunity of guidance under MRI control (Hagspiel et al., 1998).

Last but not least, prototype robot systems exist for placing the puncture needle based on the information provided by tomography and fluoroscopy (Su et al., 2002).

3.6.2 Choosing the Puncture Site and the Type of Approach

The choice of the puncture site and type of approach (subcostal, supracostal, or combined) is made considering the particularities of the patient, the location, and complexity of the lithiasis.

The percutaneous puncture of the pyelocaliceal system requires a prior detailed anatomical evaluation, which may reveal possible changes of the collecting system (Sampaio and Mandarim-de-Lacerda, 1988).

The preferred approach for puncturing the pyelocaliceal system is achieved through the papilla of a posterior calyx, thus avoiding the major vascular structures of the kidney (Gupta et al., 2007). The direct puncture of the renal pelvis must be avoided because of the risk of injuring the posterior branches of the renal artery (Gupta et al., 2007). On the other hand, in the case of an inadequate transparenchymal tract, significant bleeding may occur while dilating the tract (Boja et al., 2008).

The lower polar approach is preferred by most urologists, being associated with fewer complications than upper pole punctures and allowing the use of the rigid nephroscope at its maximal potential (Kim and Lingeman, 2006).

The supracostal approach is preferred when the lithiasic mass is situated at the level of the upper renal pole calyces or in the case of horseshoe kidneys, with a usually low position (Lam et al., 1992). Supracostal approach also has the advantage that the puncture line is aligned with the renal axis, allowing easy access to the pyeloureteral junction and the proximal ureter. Sometimes, access to the upper pole can be obtained by subcostal approach. However, the intercostal approach is frequently necessary, especially for a solitary upper caliceal stone or an upper caliceal diverticulum with lithiasis (Kim and Lingeman, 2006).

3.6.3 Puncture Technique

The first step is represented by placing a ureteral catheter through a transurethral approach (Fig. 3.29) (LeRoy, 2006). After being placed, it is fixed to the Foley catheter and the patient is repositioned in the position chosen by the surgeon, in order to access the pyelocaliceal system.

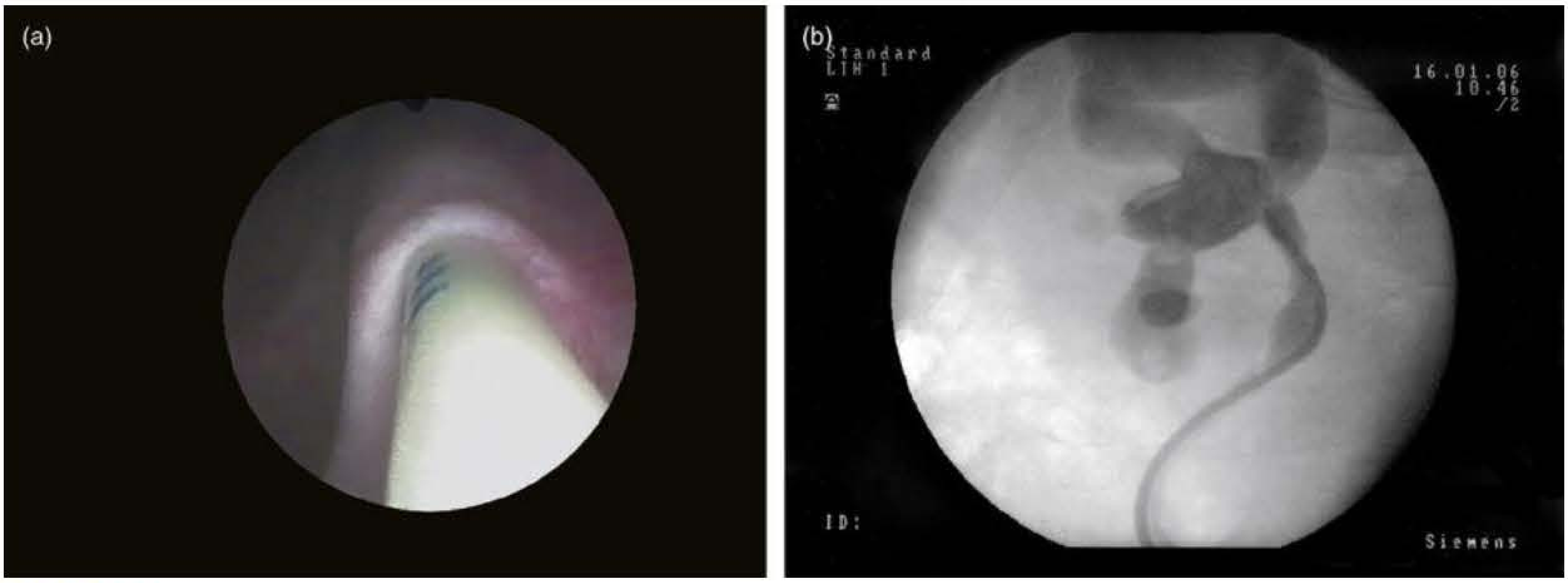


FIGURE 3.29 **Placing the ureteral catheter (a) and performing retrograde pyelography through it (b).**

The fluoroscopic evaluation of the pyelocaliceal system during retrograde pyelography is essential for choosing the calyx that will be punctured (LeRoy, 2006).

The elective path is represented by a calyx oriented posteriorly. In order to identify such a calyx, a small amount of air or carbon dioxide can be injected into the pyelocaliceal system, already opacified with contrast medium (Salomonowitz et al., 1984). On the other hand, carbon dioxide or air can be used alone for pyelography in patients with severe allergies to the contrast medium (LeRoy, 2006). The advantage of this maneuver consists of the fact that in patients in prone position, the gases, which are lighter than the contrast medium, are distributed first to the posterior calyces, which become more transparent, while the anterior calyces remain opaque (Gupta et al., 2007).

Visualization of the pyelocaliceal system using double contrast for differentiating the anterior calyces from the posterior ones is necessary, especially in case of significant hydronephrosis on a policystic kidney or in case of a malrotated kidney, when there is a superposition of the images of the dilated calyces (Boja et al., 2008).

Percutaneous puncture can be achieved with an 18–22 G needle with a mandril (Seldinger technique) or with trocar systems. Regarding the latter, they have almost completely been abandoned lately, being mentioned by us only for historic reasons (Soltes et al., 1998; Dyer et al., 2002).

There is the possibility of an initial exploratory puncture with a thinner 21 or 22 G needle. After checking that the initial puncture was correct, a second definitive puncture with a thicker 18 G needle will be performed. This maneuver can be performed under fluoroscopic guidance, along the initial puncture tract or by coaxial puncture using the Mitty-Pollack-type needle (Wong, 2009).

3.6.3.1 Subcostal Approach

The puncture site at the skin level, in the case of the lower calyx, is represented by the intersection between the posterior axillary line and the longitudinal axis of the calyx that will be approached (Fig. 3.30) (Boja et al., 2008). The ideal puncture site should provide the shortest access route to the calyx, below the XII-th rib.

The needle is inserted through the skin or through a 1-cm wound created previously on the posterior axillary line, below the XII-th rib, and in its path it will meet two areas of resistance: the aponevrosis of the transverse muscle and the kidney's capsule (Boja et al., 2008).

The use of the fluoroscope allows to determine a tridimensional access tract (LeRoy, 2006). Thus, examination with the arm of the fluoroscope at 90° highlights the vertical plane medial to the entrance into the required calyx. The fluoroscope is subsequently rotated by 30° toward the surgeon, in order to define the horizontal plane. The intersection between these two defines the point of entrance into the system (Gupta et al., 2007).

With the fluoroscope in this position, an 18 G puncture needle is advanced in this plane, using the bull's-eye technique (Gupta et al., 2007). A shorter needle is preferred, which is easier to control. This effect is clear when the plane of the needle is the same with the plane of the fluoroscope.

After identifying the correct position, the puncture needle is advanced gradually by the surgeon, in steps of 1–2 cm (Gupta et al., 2007). The depth of the needle's insertion can be monitored by rotating the fluoroscope back to the initial vertical position (Gupta et al., 2007).

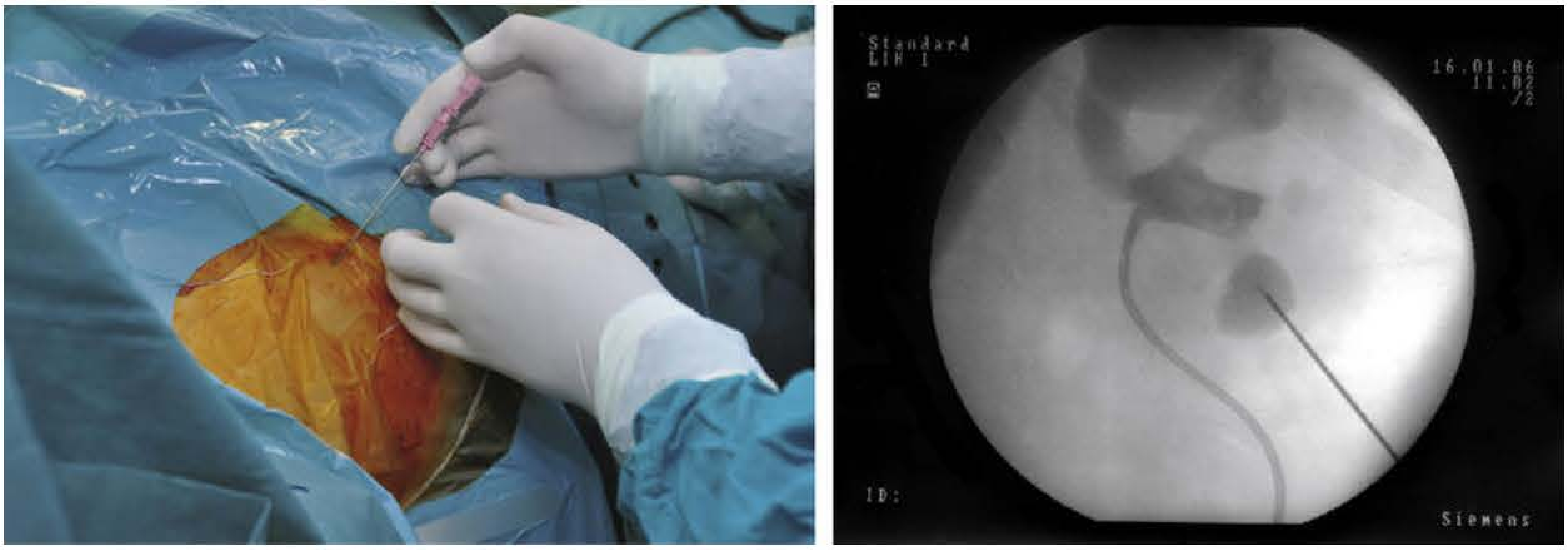


FIGURE 3.30 **Subcostal puncture on the posterior axillary line.**

Periodically, by rotating the fluoroscope's arm by 30° toward the surgeon, the bull's-eye effect can be observed, thus allowing to evaluate if the needle's direction of advancing is correct, trying to make the needle's tip reach the required calyx, in both fluoroscopic planes (Gupta et al., 2007).

An attempt is made to enter a posterior calyx, aligning the direction of access with the axis of the calyx which is to be punctured, in the attempt to cross a minimal thickness of the cortical parenchyma, and a transpapillary perforation of the calyx (Wong, 2009).

The deformation of the caliceal papilla is observed fluoroscopically, and a sensation of emptiness is perceived after entering the lumen of the calyx (Boja et al., 2008).

After inserting the puncture needle into the pyelocaliceal system, the needle's mandril is removed, the correct position being confirmed by leakage, spontaneous (Fig. 3.31) or after aspiration, of the contrast medium and/or urine.

Puncture using a renal radiopaque stone as a landmark can be a solution when the retrograde catheter cannot be inserted (due to anatomical reasons), and the contrast medium cannot be introduced intravenously (kidney failure, allergy to contrast medium) (Boja et al., 2008).

A thin puncture needle is advanced toward the opaque stone, and contrast medium is injected if it is successfully inserted into the pyelocaliceal system and urine is aspirated (Tabibi et al., 2007). If the puncture tract is correct, the operatory maneuvers can be continued, and if not the puncture is repeated under fluoroscopic guidance with the help of contrast medium injected through the initial needle (Tabibi et al., 2007).

Comparing the puncture of the pyelocaliceal system, with or without retrograde pyelography, Tabibi et al. (2007) did not observe any differences regarding the results, operatory time, duration of hospitalization, or exposure to radiation.

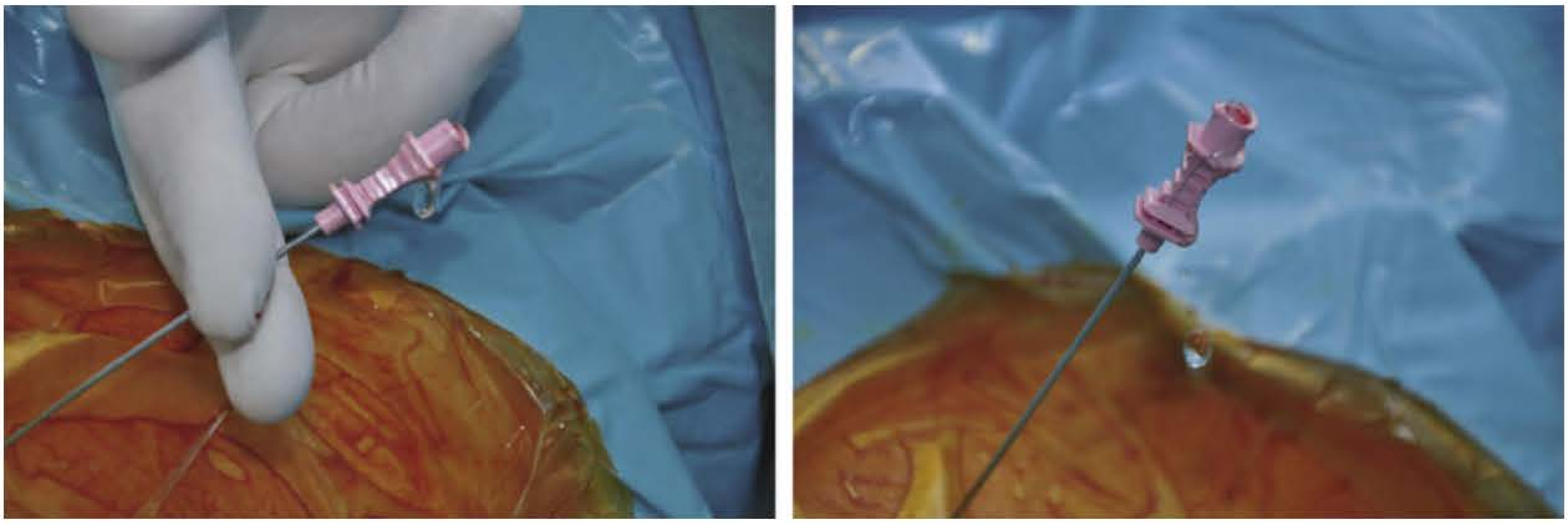


FIGURE 3.31 **Evacuation of urine through the needle, confirming the puncture of the pyelocaliceal system.**

The percutaneous nephrolithotomy tract must be perfectly straight in order to perform the intervention in favorable conditions, and the direction of the needle can be corrected during the intervention only after retracting it into the subcutaneous fatty tissue (Boja et al., 2008).

Subsequently, under fluoroscopic control, a rigid enough guidewire (Zebra, Landerquist) can be advanced inside the needle up to the collecting system. This can be inserted through the pyeloureteral junction or, most frequently, into the renal pelvis or upper calyx, where it should form a loop.

3.6.3.2 Intercostal Approach

The purpose of the intercostal approach is usually to puncture a middle or upper calyx. This is most frequently performed between the XI-th and XII-th ribs, but it can also be performed between the X-th and XI-th ribs. Due to its potentially increased morbidity, some authors do not recommend access above the XI-th rib, except when there is no other option (Fuchs and Forsyth, 1990).

The puncture technique is not significantly different than the puncture through a subcostal approach, and a posterior calyx is most frequently chosen.

In the case of an intercostal approach, in order to prevent injuring the intercostal vessels and nerves located on the inferior edge of the suprajacent rib, the puncture must be performed in the lower half of the intercostal space (Boja et al., 2008). On the other hand, it is recommended to perform the puncture through the intercostal approach while exhaling, in order to avoid intercepting the pleura and the lower pulmonary lobe (Boja et al., 2008).

In a series of 115 procedures of percutaneous nephrolithotomy by supracostal approach, Golijanin et al. (1998) described a satisfactory rate of complications of 8.7%, and a stone-free rate of 87%.

3.6.4 Upper Caliceal Puncture Techniques by Subcostal Approach

3.6.4.1 Intercostal Percutaneous Approach With Caudal Kidney Mobilization

This maneuver consists of placing the Amplatz sheath at the level of a lower or middle calyx and pushing it cranially, thus obtaining the caudal displacement of the kidney. Under fluoroscopic control, a second puncture is subsequently performed at the level of the upper pole or a puncture in "Y" (Karlin and Smith, 1989).

3.6.4.2 Triangulation

Triangulation is another technique for accessing the upper calyx. In this case, with the fluoroscope's arm positioned vertically and maintained in this position, retrograde pyelography is performed and the skin above the calyx that will be approached is marked (Gupta et al., 2007). This plane defines the medial extension of the needle's insertion. The fluoroscope is rotated by 30° toward the surgeon, and the skin above the target calyx is again marked lateral to the first site (Gupta et al., 2007). The surgeon uses this point from the level of the skin to describe an inferior vertical line up to 1–2 cm below the XII-th rib. This third point represents the cutaneous puncture site, from which the needle is advanced up to the junction between the vertical plane and the 30° plane (Gupta et al., 2007).

Thus, using this technical artifice, access is obtained at the intersection between the three axes, from which the term triangulation derives (Niles and Smith, 1996).

3.6.5 Particularities of Puncture Under Ultrasonographic Guidance

The principles of a correct percutaneous puncture under ultrasonographic guidance do not differ significantly from those of access under fluoroscopic control (Gupta et al., 2007). After transurethral insertion of the ureteral catheter, the patient is repositioned usually on the flank, and under ultrasonographic control, using a 3.5 MHz transducer in coronary section, the stone and the pyelocaliceal system are highlighted (Karami et al., 2010). Fifty mL of saline solution can then be inserted through the ureteral catheter in order to induce hydronephrosis, if this is not present (Karami et al., 2010). On the other hand, puncture under ultrasonographic guidance can also be performed in good conditions in prone or supine position.

When the puncture needle enters the dilated cavity of the calyx, this can be perceived as a very echoic point or line, a phenomenon called echolucence (Boja et al., 2008). However, the needle's tip can be difficult to detect at ultrasonography, and the success of the puncture is confirmed by the leakage of urine through the needle, after removing the mandril (Gupta et al., 2007).

For a better control of the insertion of instruments into the pyelocaliceal system, the surgeon can position the transducer at the level of the anterior abdominal wall (Karami et al., 2010). In order to reduce the kidney's mobility, both the puncture and the tract's dilation should be performed in the same phase of breathing (either inhaling or exhaling), applying manual extra-abdominal compression or through the transducer (Karami et al., 2010). The Doppler module can sometimes be useful for determining the neighboring vascular structures.

If only the renal pelvis can be detected at ultrasonography, a thin 22-gauge needle can initially be used for puncture, allowing for antegrade pyelography before the definitive puncture (LeRoy, 2006).

3.6.6 Particularities of Endoscopically Guided Puncture

This method involves ascending a flexible ureteroscope up to the pyelocaliceal level on a previously placed guidewire. In the case of patients in prone position, with the legs spread apart, the guidewire will be inserted with the help of a flexible cystoscope. In supine position, the legs will be positioned in the classic lithotomy position, and the guidewire will be inserted with the help of a rigid cystoscope.

Whatever the position, this modality has the advantage that it does not involve repositioning the patient. Of course, performing the intervention requires two operators.

After choosing the desired calyx under visual control, pyelography can be performed through the ureteroscope, the puncture then being carried out in excellent conditions (Khan et al., 2006). This is done under fluoroscopic control, using as a landmark the tip of the flexible ureteroscope, while the correct transpapillary placement of the needle is visually confirmed (Gupta et al., 2007).

In a number of 12 patients in whom ureteroscopically guided percutaneous approach was used, Khan et al. (2006) reported achieving a successful access in all cases, with a stone-free rate of 73%.

The percutaneous approach under ureteroscopic control can be useful especially for undilated pyelocaliceal systems, complex renal lithiasis, ectopic or malrotated kidney, and for patients with morbid obesity (Khan et al., 2006).

3.6.7 Particularities of Puncture in Supine Position

From a technical point of view, the puncture in supine position has certain particularities. For experienced urologists, this can be easier than in prone position.

In supine position, the colon falls antero-medially, thus moving further away from the puncture route, therefore minimizing the risk of intercepting it (Cormio et al., 2007).

Due to the fact that in different variants of the supine position the flank is raised by approximately 20°, the puncture needle's plane is almost horizontal (Hoznek et al., 2011). The puncture site is located on the posterior axillary line, and with the fluoroscope in a vertical position the needle is perpendicular to the fluoroscope's axis (Hoznek et al., 2011). In order to determine the position of the needle's tip in relation with the target calyx, the fluoroscope must be inclined by 30°, in a manner similar to that previously described for puncture in prone position (Hoznek et al., 2011). The puncture needle's inclination may be modified as much as necessary upward or downward, but it must always remain in the plane that crosses through the caliceal infundibulum's axis (Hoznek et al., 2011).

The Galdakao-modified supine Valdivia position allows retrograde access simultaneously with the puncture maneuvers. Practically, one surgeon performs cystoscopy and retrograde ureteral catheterism, while the second performs the puncture (Hoznek et al., 2011).

3.6.8 Particularities of Puncture in Lateral Position

Percutaneous puncture in these situations is easier in case of morbid obesity or severe cifoscoliosis (Ray and Honey, 2012). This position also requires placing a retrograde ureteral catheter and pyelography, maneuvers which are performed in supine position, thus involving patient repositioning.

Usually, puncture in lateral or lateral-flexed position is achieved under ultrasonographic guidance (Karami et al., 2010). On the other hand, fluoroscopy is technically limited due to the restriction of the fluoroscope's arm rotation arch and to the poorer radiological visualization of the collecting system. In this situation, triangulation can be an extremely useful technical artifice (Ray and Honey, 2012). These variants of positioning may allow an easier identification of the posterior calyces, thereby facilitating the puncture (Ray and Honey, 2012).

3.6.9 Puncture by Retrograde Approach (Lawson Technique)

This type of puncture implies the use of a deflectable guidewire, with a three-ring-type handle. This guidewire is inserted on a cystoscope, and its distal end is directed toward the calyx selected for access. A 7 F catheter slides on it into the calyx, after which the guidewire is removed. A flexible needle will then be inserted through the catheter, which will pierce the renal parenchyma, the perirenal tissues and the muscle layers and will deform the skin. The needle will be pushed with jerky motions, 1–2 cm at a time, with a higher success rate than the attempt to advance it over longer distances in a single maneuver. The existence of scar tissue in the needle's path may prevent its progression, and any attempt to push it will change the position of the catheter in the calyx.

If the site where the needle deforms the skin is considered to be convenient by the surgeon, an incision will be made with the scalpel and the needle will be exteriorized. The dilation maneuvers are continued in an antegrade manner, while the distal end of the catheter will be withdrawn to the renal pelvis level and will subsequently be used for injecting the contrast medium (Hosking, 2006).

3.7 DILATION OF THE PUNCTURE TRACT

After performing the percutaneous puncture and thus obtaining access to the pyelocaliceal system, the next step is represented by the dilation of this tract in order to allow the insertion of endourological instruments.

Dilation of the nephrostomy tract represents an essential step in renal percutaneous surgery, the success of the intervention depending on it in a great manner. The insertion of the nephroscope into the renal collecting system requires the dilation of the puncture tract to 24–30 Ch, a procedure that is carried out on the previously inserted guidewire.

In the initial period of percutaneous interventions, the dilation of the nephrostomy tract was done gradually, using sequential telescopic dilators, over a period of up to 8 days (Gupta et al., 2007). Acute dilation of the nephrostomy tract in a single session without complications was only described in 1982 (Castaneda-Zuniga et al., 1982).

Dilation must be carried out with minimal trauma, avoiding as much as possible to determine associated lesions.

3.7.1 Inserting the Metallic Guidewire

The basic principle of acute dilation of the nephrostomy tract is that it must be performed on a guidewire. After puncture of the collecting system, a "J"-type guidewire is advanced through the needle's lumen using the Seldinger technique (Gupta et al., 2007).

The guidewire, which must be rigid enough to allow the dilation maneuvers, is advanced up to the level of the renal pelvis (Fig. 3.32) and eventually through the ureteropelvic junction.

If this cannot be inserted through the ureter, especially when the puncture is performed at the level of the lower pole, the guidewire's loop should be left in the renal pelvis or, even better, pushed toward a calyx, as far as possible from the percutaneous tract. The passage of the guidewire through the ureteropelvic junction into the ureter (even up to the bladder according to some authors) minimizes the risk of the migration of the guidewire during the fascial

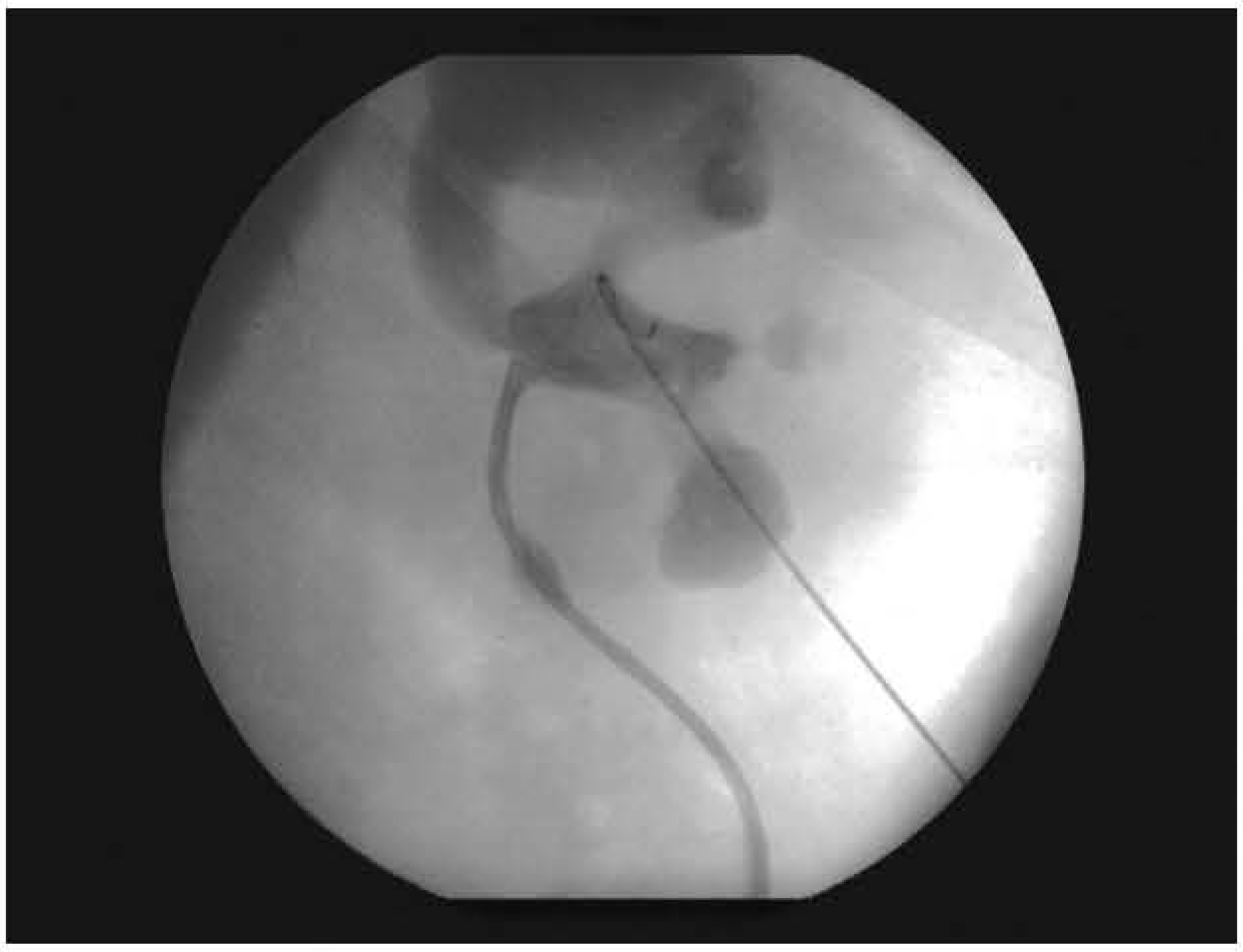


FIGURE 3.32 **Insertion of the guidewire with the loop at the pyelic level.**

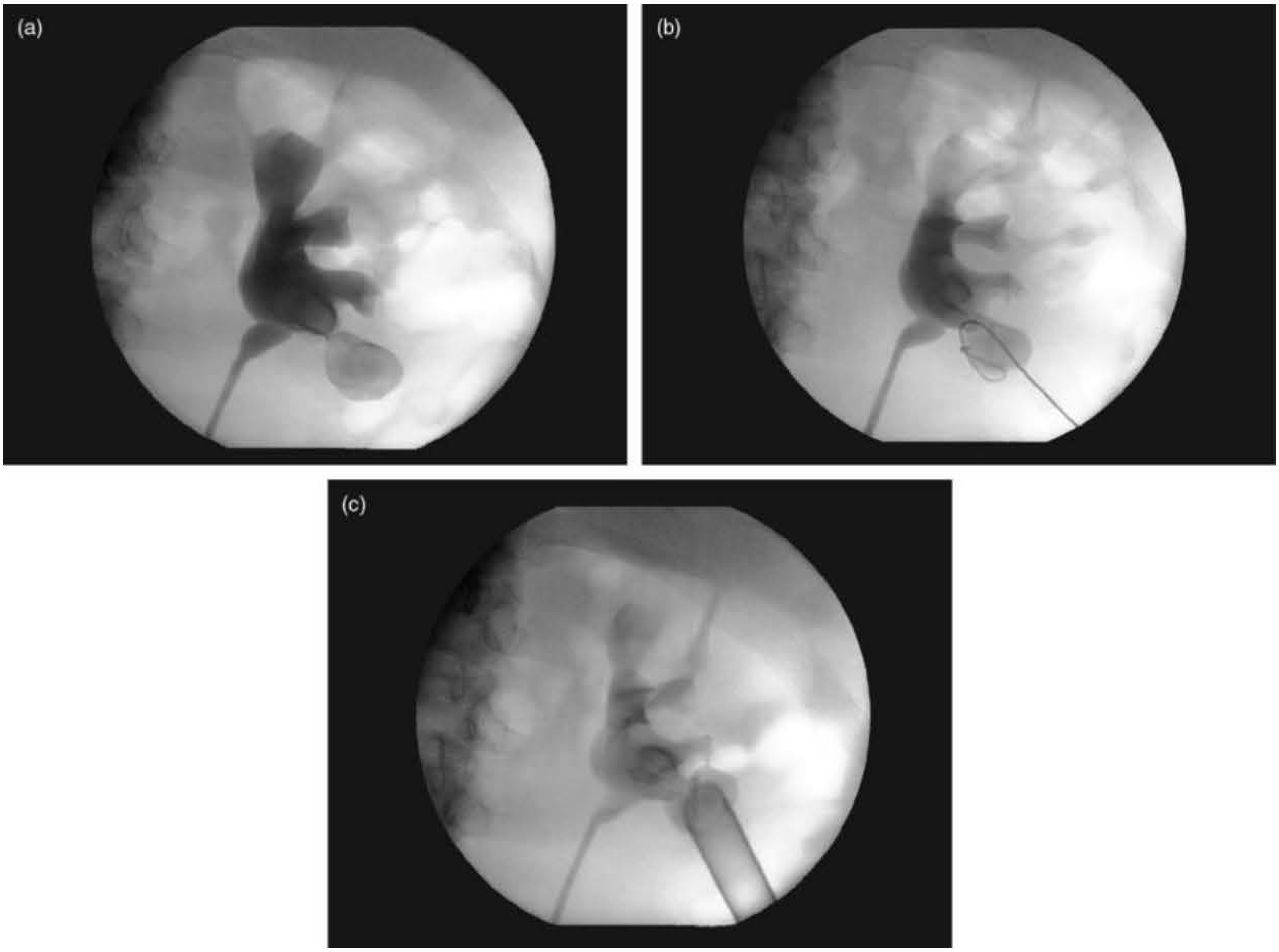


FIGURE 3.33 **Staghorn stone (a) that does not allow the passage of the guidewire into the renal pelvis (b), requiring to carry out the dilation in the stone (c).**

dilation (Gupta et al., 2007). In case of staghorn stones and sometimes of voluminous caliceal ones, the guidewire cannot overcome the caliceal infundibulum (Fig. 3.33), the risk of migration during the dilation maneuvers being high.

A second, safety guidewire can also be used with the aim of protecting the access to the pyelocaliceal level in case of the working guidewire's dislocation (Gupta et al., 2007).

Due to the risk of changing the position of the metallic guidewire, all dilation techniques require routine fluoroscopic guidance (LeRoy, 2006). Before removing the needle, incision of the skin (usually of approximately 10 mm) and of the fascia is performed, in order to effectively dilate the percutaneous tract.

3.7.2 Preliminary Dilation

The preliminary dilation of the tract is carried out with 2–3 bougies-type Teflon fascial dilators of 6–8 Ch inserted on the guidewire, or with a Storz-type metallic dilator (Fig. 3.34) (Boja et al., 2008). The fascial dilators must be inserted under fluoroscopic control along the rigid guidewire, aligned with the axis of the accessed calyx, until their end reaches the collecting system (Wong, 2009).

3.7.3 Creating the Actual Percutaneous Tract

The dilation of the nephrostomy tract can be carried out with fascial, metallic telescopic, balloon, or Amplatz-type (one-shot) dilators (Yamaguchi et al., 2011). All these dilation systems are loaded on the previously inserted guidewire.

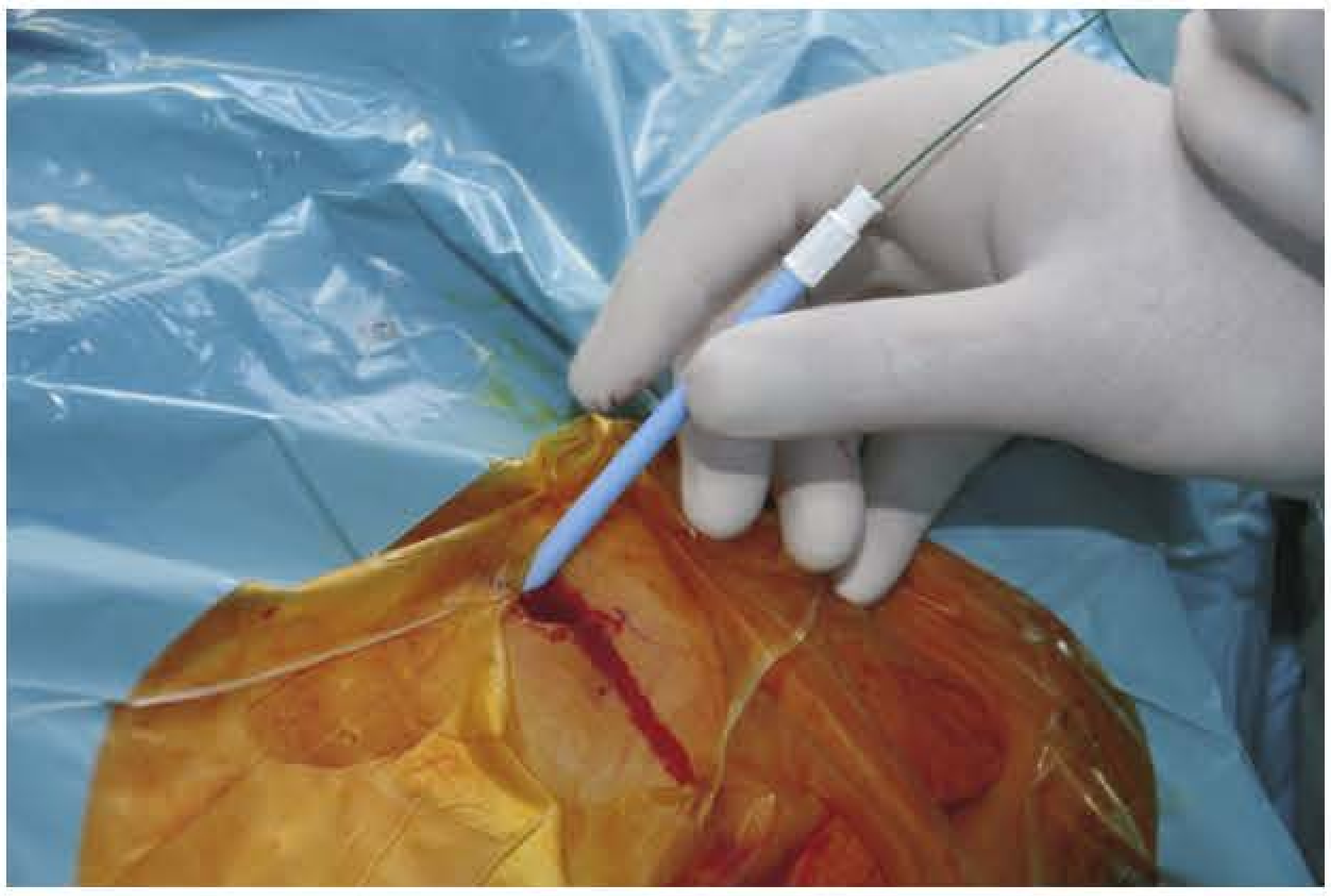


FIGURE 3.34 **Preliminary dilation with fascial dilators.**

3.7.3.1 *Fascial Dilators*

This dilation system consists of Teflon (polytetrafluoroethylene) tubes with progressive sizes from 8 Ch to 36 Ch, which are inserted on the guidewire and are advanced by rotation under fluoroscopic control (Gupta et al., 2007). This technique provides a good safety and allows the dilation of a fibrous tract in the case of patients with a history of open or percutaneous surgical interventions or after renal or perirenal inflammatory processes, perinephritis (Press and Smith, 1995).

Fascial dilator sets are relatively inexpensive and easy to use (LeRoy, 2006). The main risk of this dilation system is injury or perforation of the renal pelvis, determining leakage of the irrigation fluid and bleeding (Gupta et al., 2007). This type of dilation implies the insertion and extraction of each dilator before using the next one.

3.7.3.2 *Amplatz-Type Malleable Dilators*

Kurt Amplatz imagined the malleable dilators in 1982 (Rusnak et al., 1982).

Polyurethane catheters of 8–30 F (every 2 F) are used in the Amplatz-type serial dilation system (Microvasive, Natick, MA) (Ozok et al., 2012).

An angiography catheter is inserted initially on the guidewire, over which the wider and wider polyurethane catheters are progressively loaded (Gupta et al., 2007). The dilators are advanced on the guidewire up to the level of the caliceal lumen, while their insertion beyond this level can damage the integrity of the pyelocaliceal system or ureteropelvic junction. In the case of voluminous or staghorn lithiasis, the dilators must be advanced up to the edge of the stone (Gupta et al., 2007).

3.7.3.3 *Coaxial Metallic Dilators*

The coaxial metallic dilators are placed one over the other in a telescopic manner. The Alken-type dilator system (Karl Storz, GmbH, Tuttlingen, Germany) consists of eight metallic tubes, with a progressive diameter from 9 F to 30 F, the difference between two successive dilators being 3 F (Ozok et al., 2012). Initially, the set's axial central piece is inserted on the guidewire, with the distal olive at the level of the renal pelvis (Boja et al., 2008). Each larger dilator then slips over the previously inserted one (Fig. 3.35), allowing for a good-quality dilation, even in the presence of fibrous tissue.

Due to the rigidity of this system, even the densest perinephritic scar tissues can be dilated successfully (LeRoy, 2006). Also, they provide a continuous compression of the nephrostomy tract's walls, ensuring a better hemostasis (Thüroff and Gillitzer, 2008).

The telescopic sheaths are advanced by rotating them between the thumb and the tip of the opposable fingers, under fluoroscopic control (Boja et al., 2008).

The advantage of Alken-type dilators over Amplatz-type ones has been observed in cases in which the guidewire cannot be directed up to the renal pelvis because of the infundibular obstruction determined by the stone, the risk of losing the tract being higher for the latter. Also, another advantage is represented by the reduction in the time necessary to obtain the tract, each Amplatz or fascial dilator having to be withdrawn for the next to be inserted (Ozok et al., 2012).

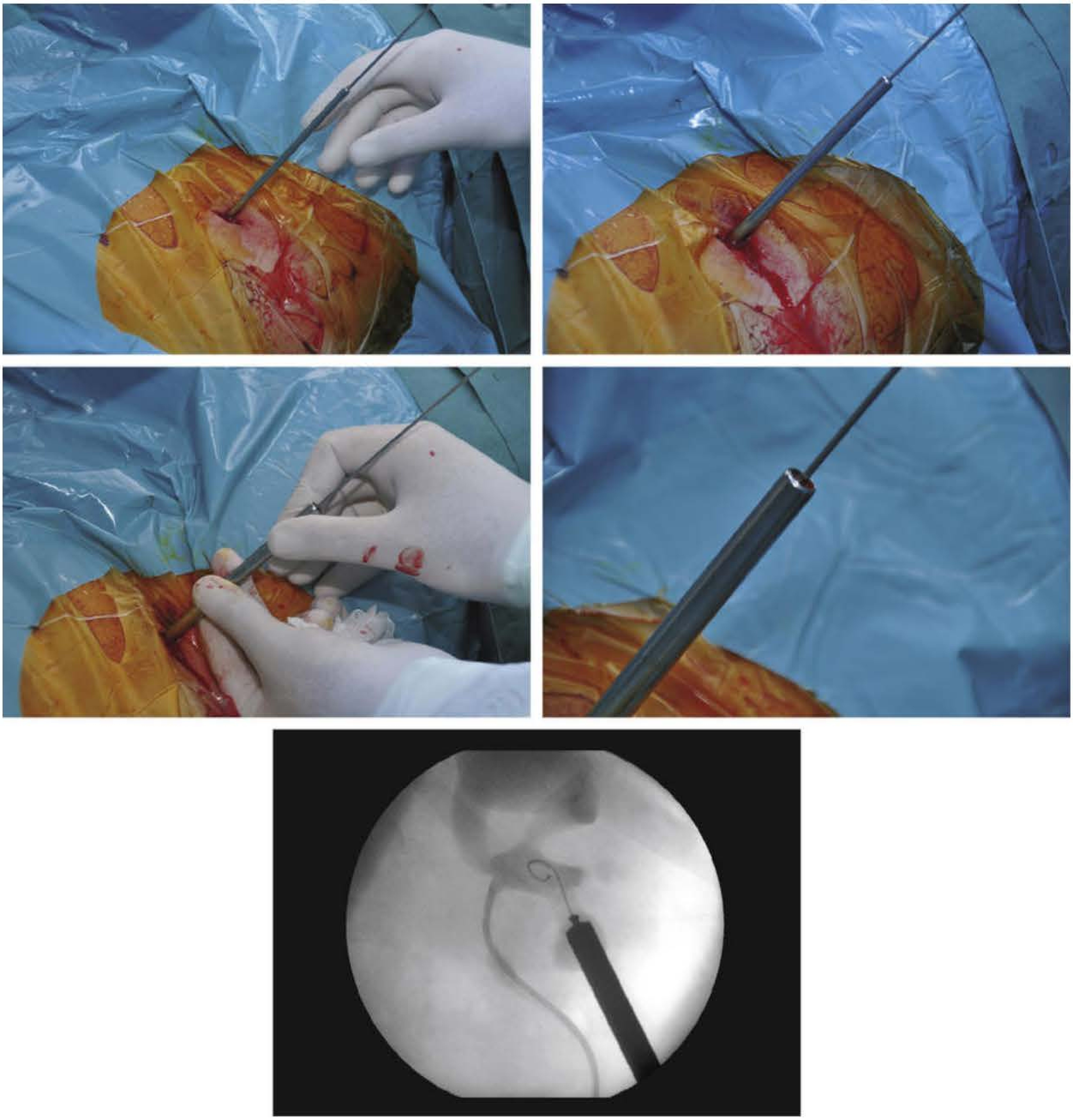


FIGURE 3.35 **Coaxial placement of the pieces of the Alken-type dilator.**

From a financial point of view, dilation with Alken-type dilators is the most inexpensive method (Falahatkar et al., 2009).

3.7.3.4 Balloon Dilation Systems

Dilation of the nephrostomy tract using balloon dilators is another alternative. It is seen as the most modern and safest method, having, however, the disadvantage of a relatively high cost (Falahatkar et al., 2009).

Balloon dilation allows to achieve the percutaneous tract in a single step, thus avoiding serial dilation. Also, it generates lateral compression forces, thus being less traumatic, but unfortunately also less efficient in the case of dilation in a dense or cicatriceal fascial tissue (Gupta et al., 2007). Some authors have reported significantly less bleeding in the case of balloon dilation compared to Amplatz-type sequential dilators (Davidoff and Bellman, 1997).

Before inserting the deflated device, the working sheath is placed behind the balloon. The catheter's tip is inserted under fluoroscopic control up to the caliceal level and, after checking its correct position, the balloon is inflated, thereby achieving dilation. Next, the external sheath is advanced under fluoroscopic control, through a pushing and rotating motion (Gupta et al., 2007). The balloon's inflation must be monitored fluoroscopically because it prevents potential complications related to its faulty initial position at the level of the junction or other structures of the collecting system (LeRoy, 2006).

A pressure of approximately 4–5 atm is necessary for dilating the tract in patients without prior renal surgery, pressure which can be increased to 15–20 atm if needed (Gupta et al., 2007).

The NephroMax™-type high pressure balloon dilator (Boston Scientific, Natick, MA) achieves a quick dilation because both the effective dilation and the sheath's insertion are carried out in a single step (Kim and Lingeman, 2006).

3.7.3.5 Amplatz Dilator ("One-Shot" Dilation)

The "one-shot"-type acute dilation technique is achieved in a single step and consists of a single dilation of the nephrostomy tract with a 28–30 F reusable Amplatz-type dilator (Falahatkar et al., 2009).

The "one-shot" dilation technique, compared to the one that uses Alken-type telescopic dilators, has not shown an increase in morbidity while significantly reducing exposure to X-rays (Falahatkar et al., 2009).

Frattini et al. (2001) demonstrated that this type of dilation does not increase the risk of hemorrhagic complications compared to the other techniques, but they do not recommend it in the case of renal hypermobility or after prior open renal interventions.

3.7.3.6 Dilation Under Ultrasonographic Control

The dilation of the puncture tract can also be achieved in good conditions under ultrasonographic control (Karami et al., 2010).

Karami et al. (2010) performed "one-shot"-type dilation of the tract under ultrasonographic control and considered that a very important aspect during the maneuver was the reduction of the kidney's movements, thus reducing the risk of perforation of the pyelocaliceal system.

3.8 PLACING THE WORKING SHEATH

For any dilation technique, the last step is represented by the insertion of the external working sheath, which can be the metallic working sheath of the 24–26 F nephroscope or an Amplatz-type external sheath.

The latter is placed by coaxial loading on the dilation system and by progressive sliding, aided by a rotation motion (Fig. 3.36).

It is fluoroscopically checked if the sheath's distal end has reached the pyelocaliceal system (Thüroff and Gillitzer, 2008). This must usually be left at the caliceal level because advancing it into the renal pelvis increases the possibility of lesions and the risk of overpassing the stone, which will remain masked beneath the sheath.

The external sheath, which ensures access to the kidney, allowing repeated insertion and withdrawal of the endoscopic instruments, has dimensions varying between 28 F and 34 F, its external diameter being approximately 2–4 F larger than the internal one.

3.9 EXTRACTION OF STONES

Once the percutaneous tract is obtained and eventually the Amplatz-type access sheath is placed, the rigid nephroscope is inserted. If a correct position is visually observed, at the level of the pyelocaliceal system, the working guidewire is removed, maintaining the safety guidewire, along the sheath (of course, if this was previously placed).

Visibility can be altered at this moment by blood clots occupying the pyelocaliceal system. These can be aspirated through the Amplatz sheath, aspirated with the ultrasonic lithotripter's sonotrode, or extracted with clot forceps (Fig. 3.37).

Smaller stones, of up to 9–10 mm, can be extracted in one piece, with extracting forceps (Fig. 3.38), graspers (Fig. 3.39), tripods, or basket catheters.

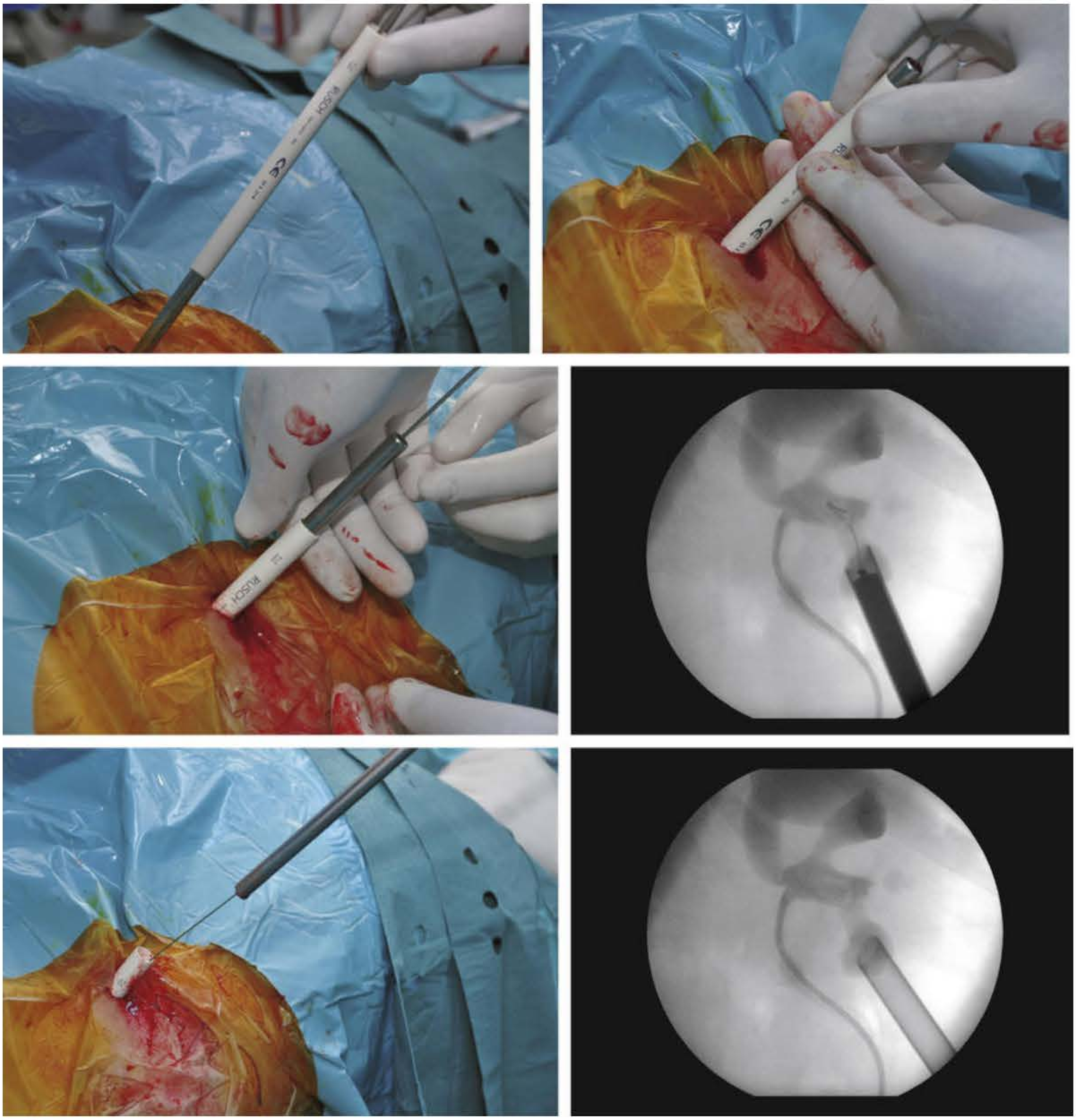


FIGURE 3.36 **Placing the Amplatz sheath on the Alken dilator.**

Larger stones must be fragmented pneumatically, electrohydraulically, by laser, or ultrasonically, and the fragments must be extracted with the previously mentioned instruments. In case of a large lithiasic mass which implies a more laborious extraction process, it is recommended to try to release the pyeloureteral junction last, in order to prevent the migration of small fragments to the ureteral level.

For the same reason, but also to optimize the operatory time, it is recommended to attempt lithotripsy of the stones into fragments as large as possible, but at the same time that fit into the Amplatz sheath.

Ultrasonic lithotripsy (Figs 3.40 and 3.41) has the advantage of also associating the possibility of suction, simultaneously evacuating the stones and sand that result after fragmentation. In order to prevent the collapse

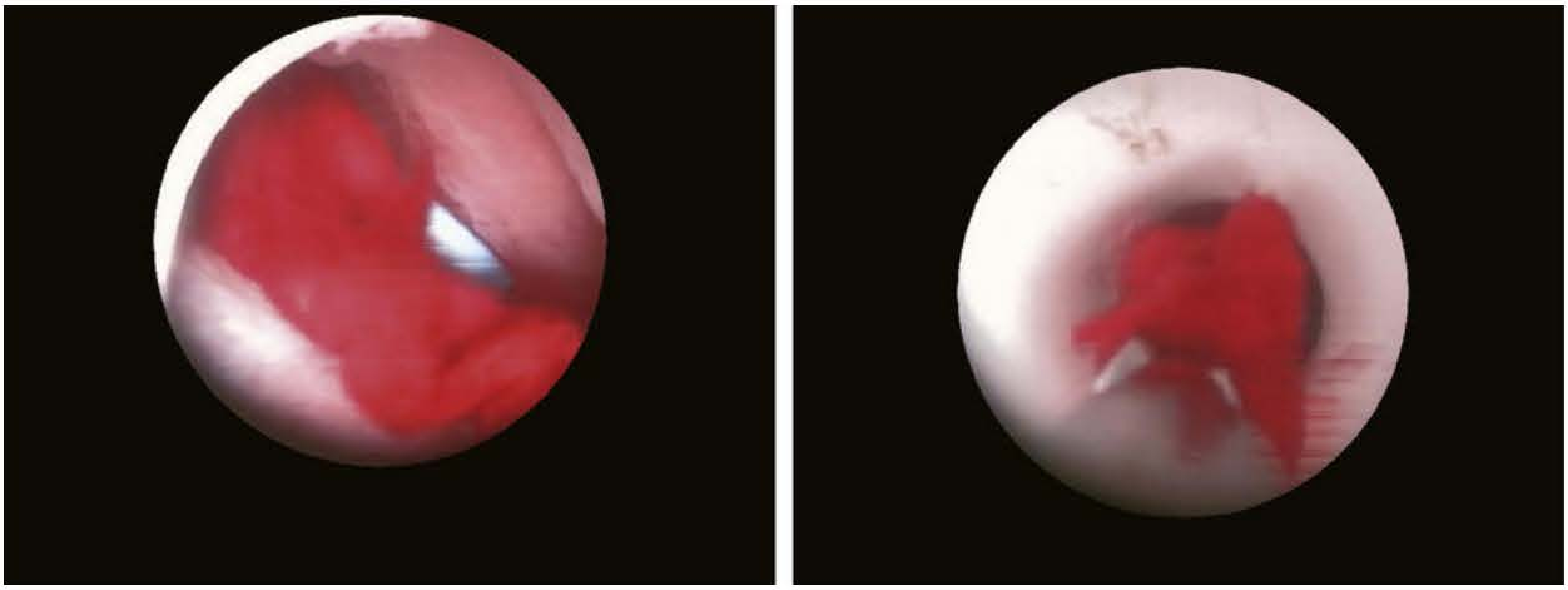


FIGURE 3.37 **Clots in the pyelocaliceal system extracted with a forceps.**

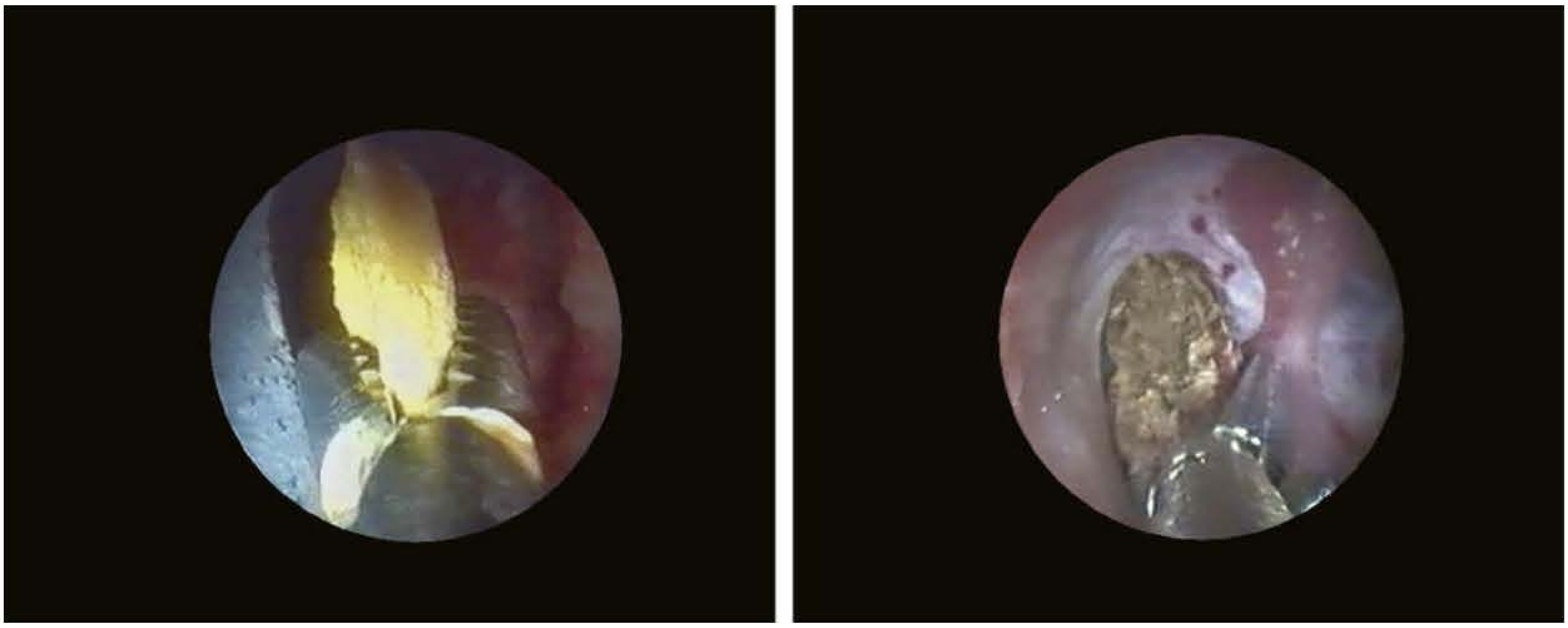


FIGURE 3.38 **Extraction of small stones with extracting forceps.**

of the pyelocaliceal walls, suction will be activated only after the sonotrode is placed in contact with the stone (Streem, 2006).

Pneumatic lithotripsy (Fig. 3.42) is a relatively safe method for fragmenting stones, but is associated with a significant retropulsion effect. Exertion of an increased pressure on the lithiasis will be avoided during the procedure, in order to reduce the risk of upper urinary tract lesions.

The stone can be fixed with the external sheath of the nephroscope during lithotripsy, thus avoiding its migration or that of the resulting fragments (Fig. 3.43).

In the case of electrohydraulic lithotripsy, saline solution will be used as irrigation fluid. The tip of the probe should be positioned 1 mm from the stone and approximately 5 mm from the distal end of the endoscope and the adjacent tissues (Zhong et al., 1997; Lingeman et al., 2007). The voltage will be initially set at 50–60 V in a single discharge or short bursts, and will be increased subsequently according to the efficiency of the lithotripsy.

The risk of perforation is lower in the case of electrohydraulic lithotripsy for caliceal lithiasis than for ureteral stones. Nevertheless, lithotripsy of stones into fragments smaller than 2 mm is not recommended because of the risk of damaging the adjacent tissular structures by electric discharges from the probe's tip (Knudsen and Denstedt, 2007).

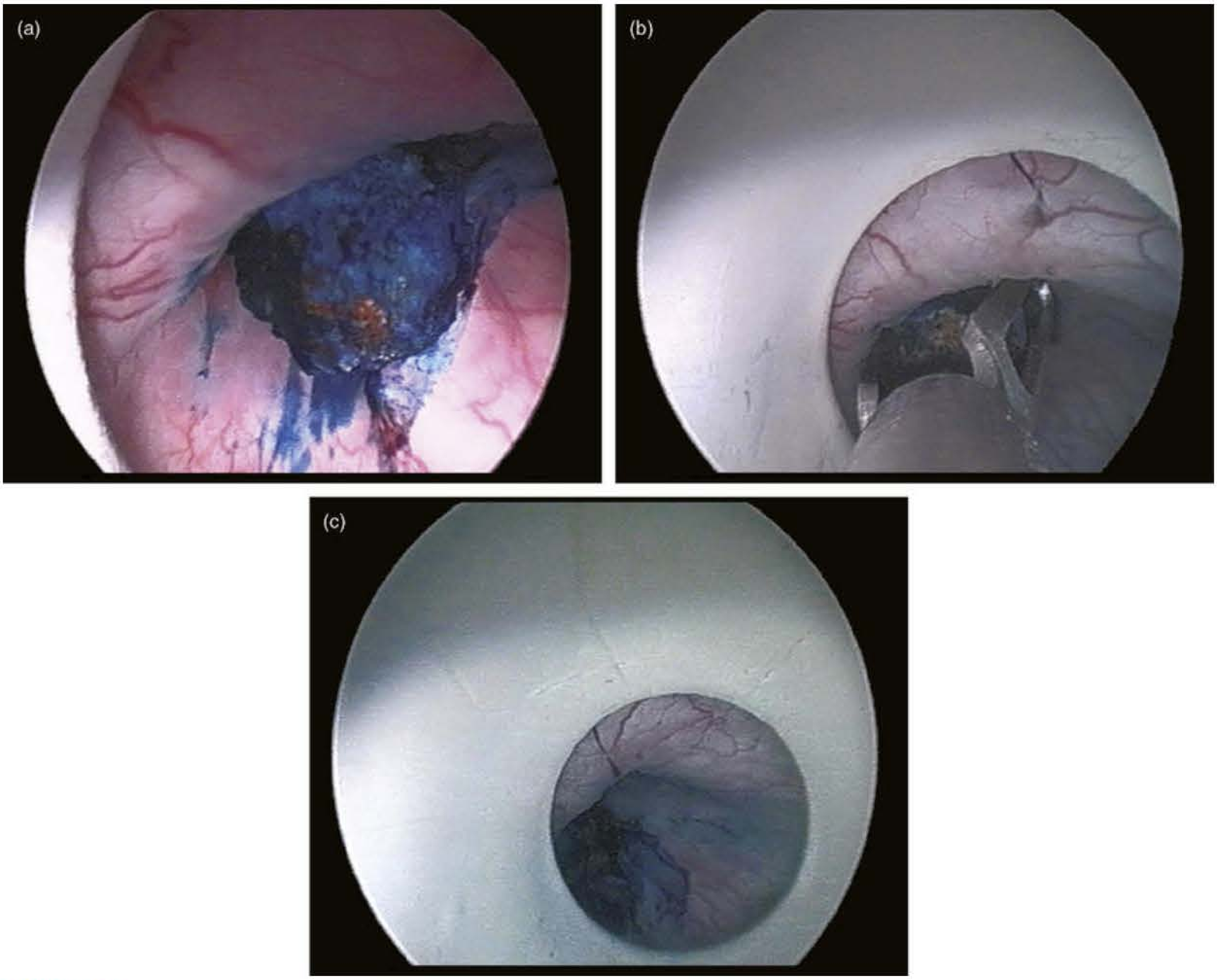


FIGURE 3.39 **Lower caliceal stone (a) extracted with the grasper-type forceps (b) and final stone-free aspect (c).**

Saline solution will be used as irrigation fluid also during Ho:YAG lithotripsy. The fiber's tip must be placed in contact with the stone (Fig. 3.44), at least 1 mm away from the neighboring structures in order to avoid tissular lesions and approximately 3 mm from the nephroscope's distal end.

For lithotripsy of renal stones, the initial settings are represented by a power of 1 J and a frequency of pulsations of 10 Hz. In the case of voluminous lithiasic fragments or when these values prove to be insufficient, a power of 1.5 J and a frequency of pulsations of 15 Hz can be used (Knudsen and Denstedt, 2007). Also, due to this laser's potential of sectioning metal, the fiber's discharge must be avoided in the immediate proximity of the accessory instruments (especially the fine ones made of nitinol) (Honeck et al., 2006).

The entire accessible lithiasic mass will be removed progressively with rigid instruments.

One of the following alternatives will be used for extracting the stones and the inaccessible fragments or those migrated during lithotripsy:

- Creating another percutaneous tract, if the residual lithiasic mass is voluminous or if technical endowment does not include flexible nephroscopes. Multiple additional tracts may be created if necessary (Figs 3.45–3.49).
- Approach with the flexible nephroscope, which will be described separately.

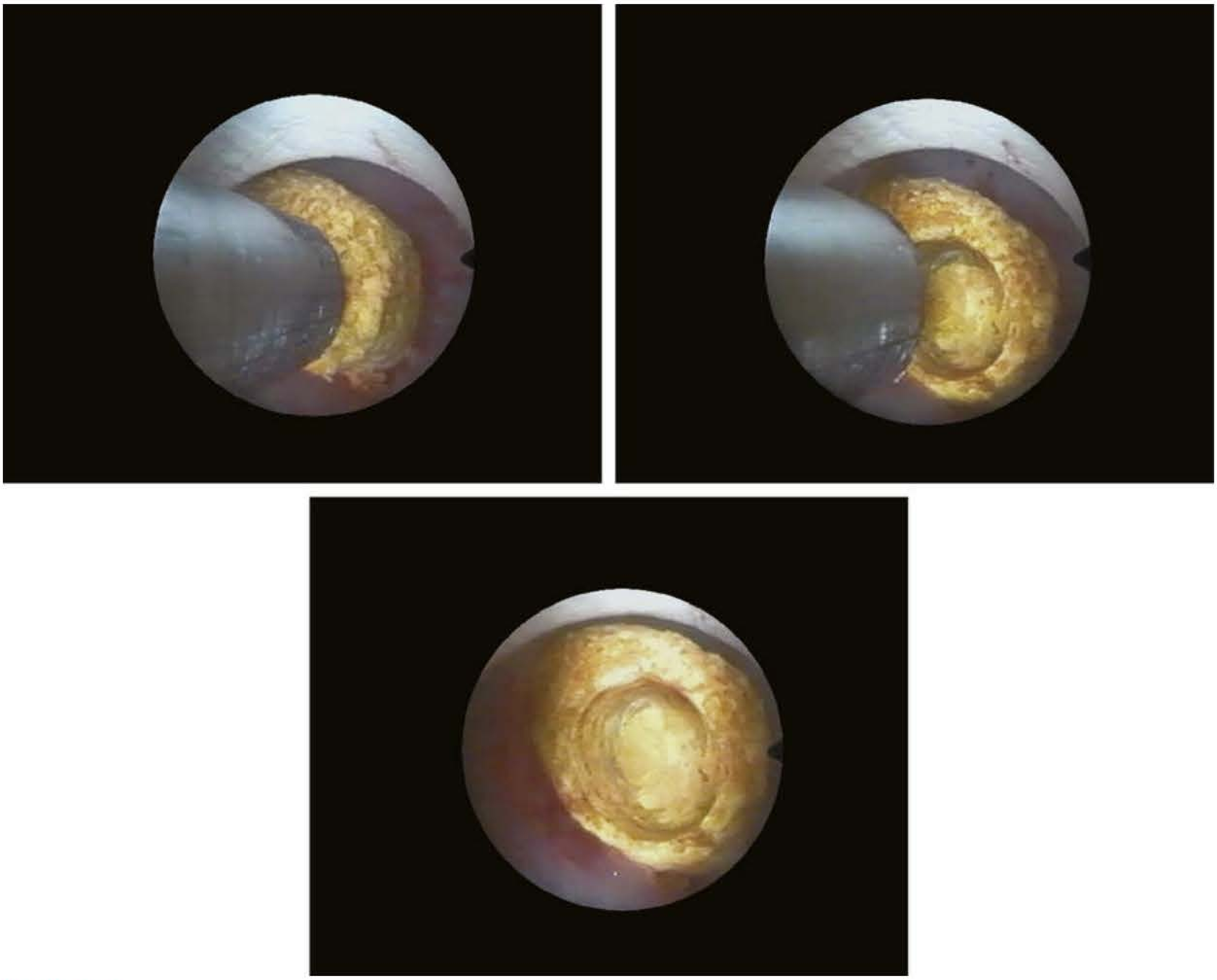


FIGURE 3.40 **Cavitation aspect of the stone due to ultrasonic lithotripsy combined with aspiration of small resulting fragments.**

- Dislocation of inaccessible lithiasic fragments, simply by puncturing the calyx where they are located, especially if they are small (Fig. 3.50). The fragments will be pushed into the area which is accessible by rigid instruments, either directly with the needle or with a jet of saline solution injected through it. In the case of fragments migrated into the ureter, the ureteral catheter will be withdrawn below them and they will be pushed cranially with a jet of saline solution or air injected through it. Repositioning at the pyelocaliceal level can also be done with the catheter itself, gently pushed cranially (Mulțescu et al., 2011).
- Interruption of the intervention and resuming it after several days, maturation of the tract determining the kidney to "fall" posteriorly, the length of the percutaneous tract to decrease, and the access angles to change. This method can be useful especially in obese patients (Streem, 2006).
- Retrograde approach with a flexible ureteroscope (the "pass the ball" technique) through which residual stones will be fragmented *in situ* or will be repositioned in an area accessible with the rigid nephroscope (Undre et al., 2004).

The complete removal of stones will be checked visually (eventually also with the flexible nephroscope) at the end of the intervention. This will be completed by fluoroscopic control, simple in the case of radiopaque stones or

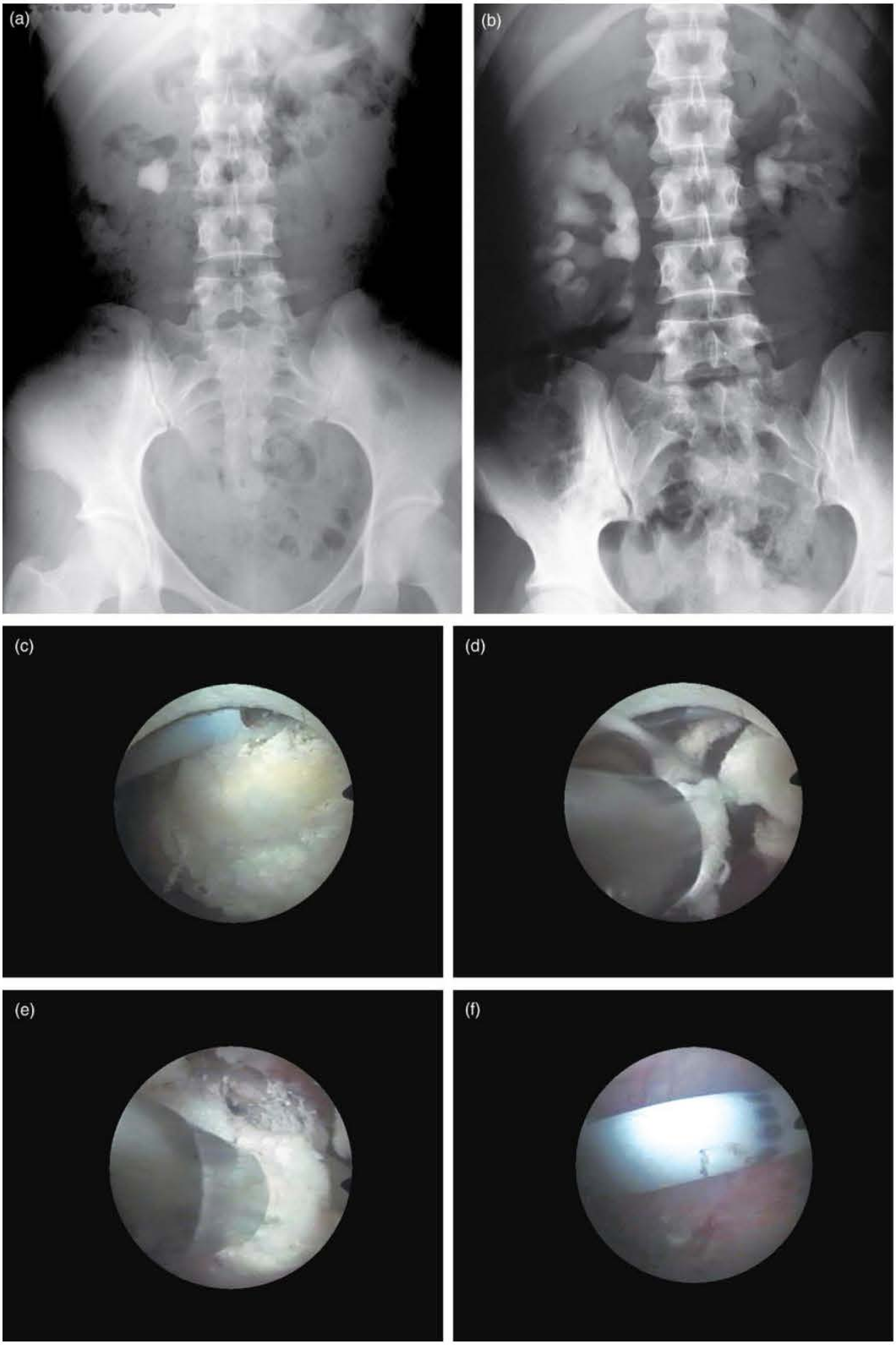


FIGURE 3.41 **Pyelic stone (a–c), fragmented ultrasonically (d, e) and stone-free aspect at the end of the intervention (f).**

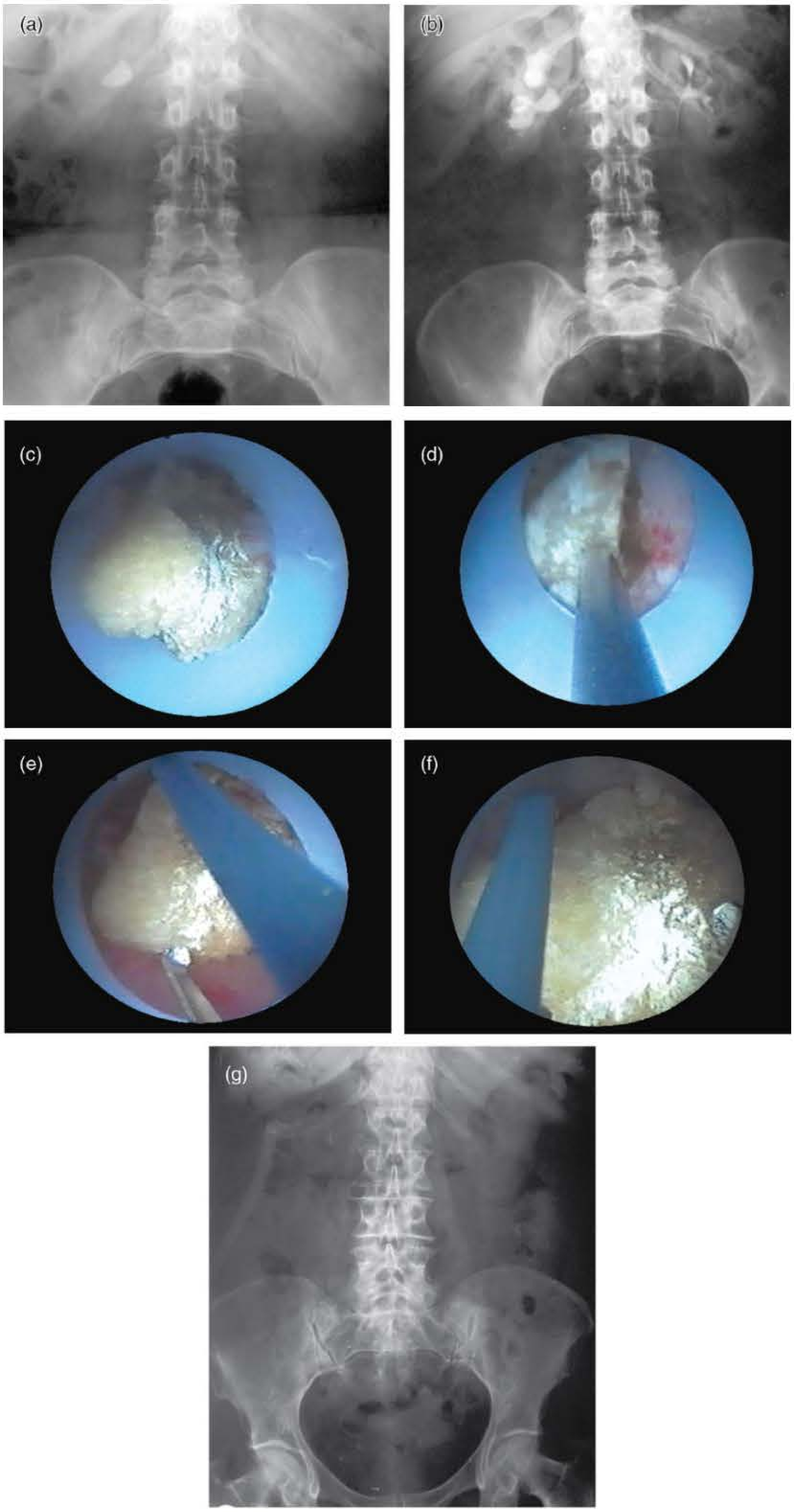


FIGURE 3.42 **Pyelic stone (a–c), fragmented ballistically (d) and extracted with the tripod grasper (e, f), with a stone-free aspect at the end of the intervention (g).**

with injection of contrast medium through the ureteral catheter after obstructing the Amplatz sheath, in the case of radiotransparent ones.

Special attention should be paid to the inspection of the ureteropelvic junction. The ureteral catheter works as an obstructive device as long as it remains at this level. Before ending the intervention, the absence of any residual fragments at the junction level must be checked (Fig. 3.51) because they have a high chance of migrating downward after the catheter is removed, determining ureteral obstruction and implicitly colic, fever and/or persistent lumbar urinary fistula.

3.10 PLACING THE NEPHROSTOMY TUBE

At the end of the intervention, a nephrostomy tube will be placed through the Amplatz sheath, and this will be withdrawn carefully, under fluoroscopic control, in order not to change its position.

For selected cases, a number of authors have introduced the term "tubeless" percutaneous interventions, without a nephrostomy tube, with ureteral stenting with a JJ catheter and placing a Foley catheter. The indications for this method are still controversial, one of them being second-look flexible nephroscopies.

3.11 PARTICULARITIES OF NEPHROLITHOTOMY USING FLEXIBLE ENDOSCOPES

3.11.1 Preoperative Preparation

The preoperative measures are identical to those preceding the percutaneous interventions using rigid instruments. The urine's sterility will be evaluated, and any coagulopathies will be excluded. The procedure will be explained to the patient and a signed informed consent will be obtained.

3.11.2 Anesthesia

The percutaneous approach of the kidney using the flexible nephroscope (alone or associated with the rigid one) can be performed under spinal, epidural, or general anesthesia. Second-look flexible nephroscopy can also be performed under local anesthesia (instillation of the anesthetic agent through the nephrostomy tract), usually associated with administration of analgesics or analgosedation.

3.11.3 Patient Positioning on the Operating Table

This is identical to the positioning during nephrolithotomies with rigid instruments. The patient will usually be placed in prone position and will be adequately draped with sterile fields.

3.11.4 Puncture of the Pyelocaliceal System and Creating the Percutaneous Access Tract

Although access to the pyelocaliceal level during first intention flexible nephroscopy is obtained as in the case of rigid percutaneous nephrolithotomy, the criteria for choosing the puncture site are different.

In the particular circumstances described in the section dedicated to indications, flexible nephroscopy allows to choose the variant with minimal potential morbidity, regardless of the position or dimensions of the stone, and reduces the necessity for creating multiple tracts or for serial interventions.

The use of the flexible nephroscope immediately after creating the percutaneous tract can often be hindered by the impaired visibility secondary to bleeding. In these cases it is recommended to place a nephrostomy tube and to delay the intervention.

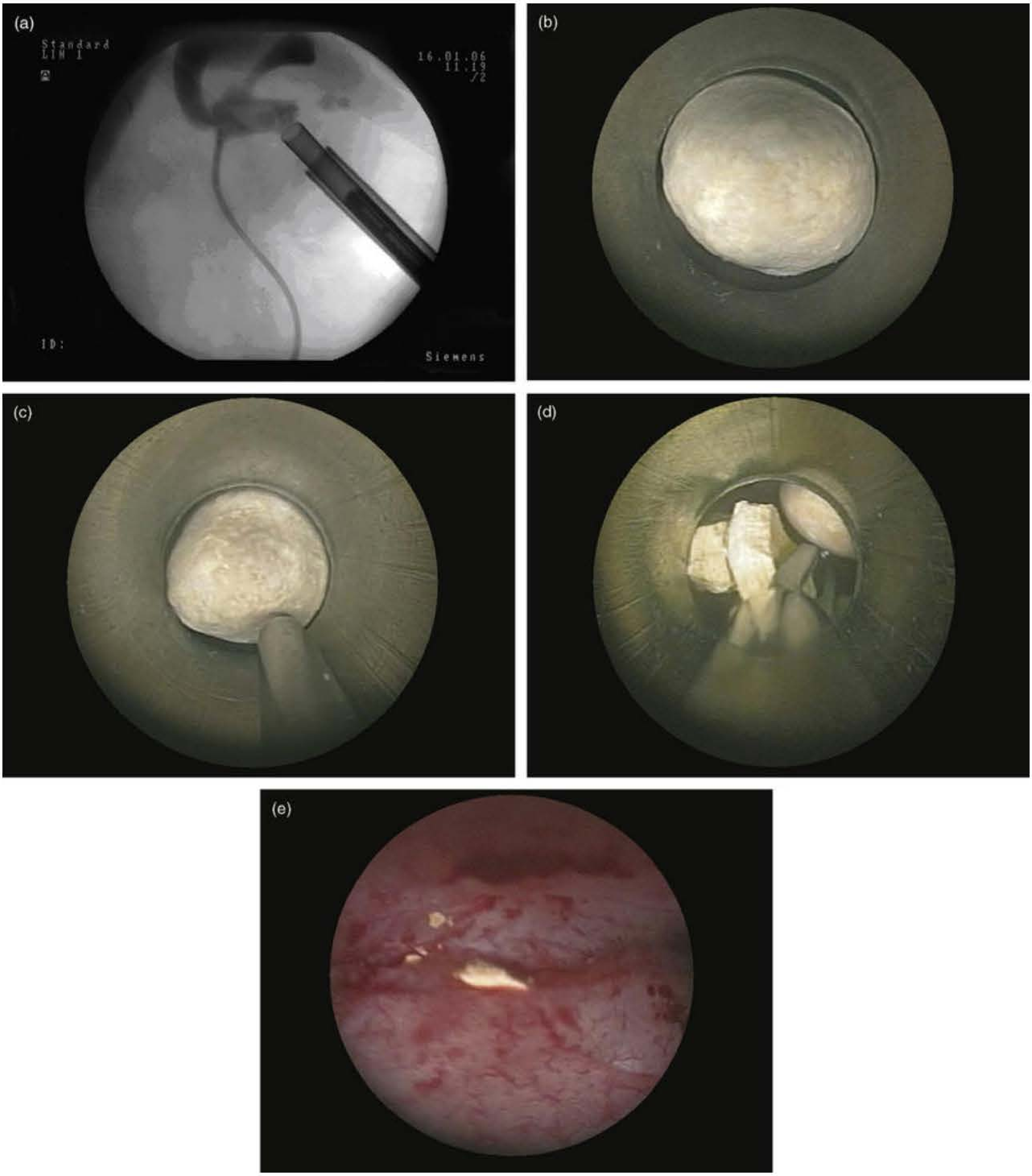

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FIGURE 3.43 **Fixation of the stone with the external sheath (a, b), its ballistic fragmentation (c), extraction with a forceps (d), and final stone-free aspect (e).**

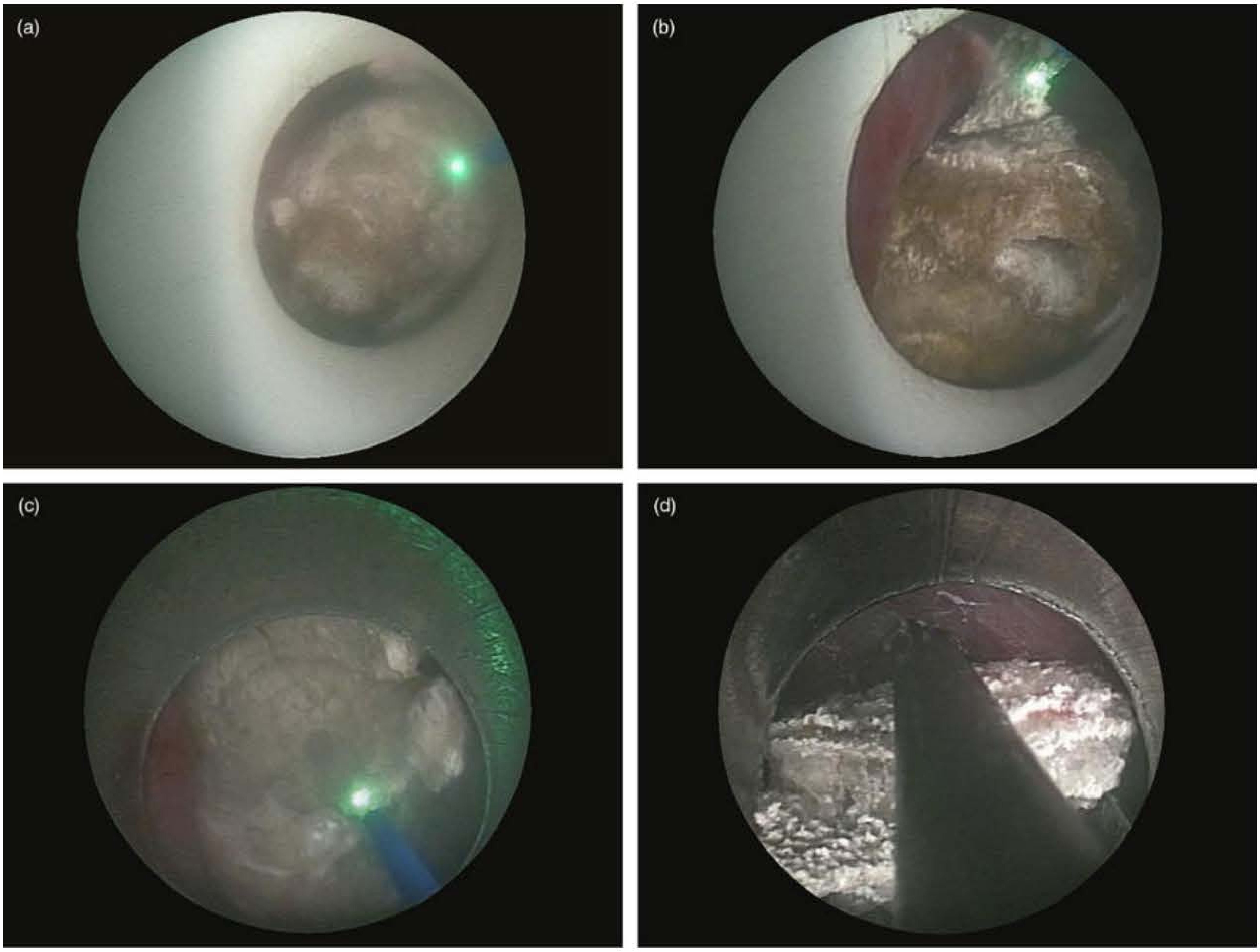

FIGURE 3.44 **Pyelic stone (a) fragmented with Ho:YAG laser (b, c) and extracted with a forceps (d).**

Second-look flexible nephroscopy is usually performed after a period of 48 h, which is usually sufficient to allow the cessation of bleeding and maturation of the tract. This interval will be prolonged if hematuria persists, so that the intervention can be performed under optimal visibility conditions. The use of the Amplatz sheath during these second-look interventions is optional.

3.11.5 Inspection of the Pyelocaliceal System

The insertion of the flexible nephroscope at the pyelocaliceal level can be done directly or through a metallic guidewire.

Due to the nephroscope's flexibility, the spatial orientation using only the endoscopic image is usually difficult. Establishing the exact position and manipulating the endoscope toward the desired areas are done under fluoroscopic control. A number of elements, such as the position of gas bubbles, can also be useful for spatial orientation.

The inspection of the entire pyelocaliceal system has the purpose of accurately identifying the position and particularities of the stones that are to be extracted or fragmented, some of which cannot be detected by imagistic examinations (Figs 3.52–3.54).

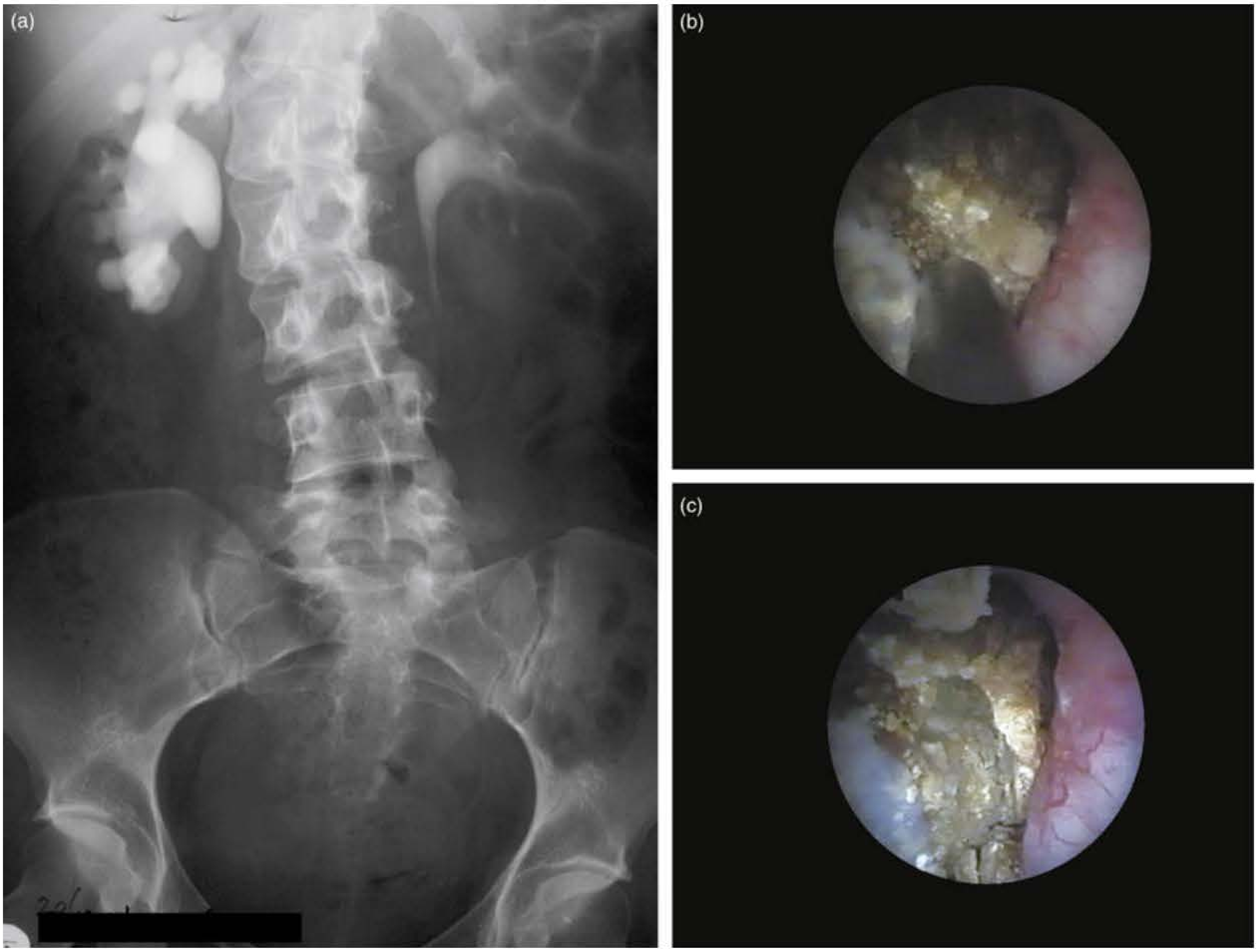

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FIGURE 3.45 **Type A staghorn stone (a), for which ballistic fragmentation and partial extraction by middle caliceal approach are performed (b, c).**

3.11.6 Fragmentation and/or Extraction of Lithiasic Fragments

Frequently, during the same intervention, flexible nephroscopy follows after the rigid one. Thus, after the lithiasic fragments accessible to rigid endoscopes have been treated under optimal conditions of visibility and using instruments with a higher caliber, which are more robust and more efficient, the rest of the pyelocaliceal system can be approached by flexible nephroscopy using the same percutaneous tract, sparing the surrounding tissues (Fig. 3.55).

Small calculi can be extracted in one piece using flexible forceps (grasper, tripod, etc.) (Figs 3.56–3.64) or tipless basket catheters. The particular shape of this type of basket catheter makes them ideal for removing caliceal stones without the risk of injuring the surrounding tissues.

Larger caliceal calculi can be treated by two modalities:

- Dislocating them to the pyelic level with the previously mentioned instruments, followed by their fragmentation using the rigid nephroscope
- "*In situ*" electrohydraulic or laser lithotripsy, eventually followed by extraction of the fragments (Figs 3.65–3.71)

The advantages and disadvantages of each energy source have already been presented. Practically, the use of one or another modality is most frequently dictated by the endowment of the respective urology department.

The lithiasic fragments obtained (even by electrohydraulic lithotripsy) are very frequently evacuated spontaneously, together with the irrigation fluid, through the Amplatz sheath. The extraction of voluminous stones requires the use of forceps or basket catheters (Fig. 3.72).

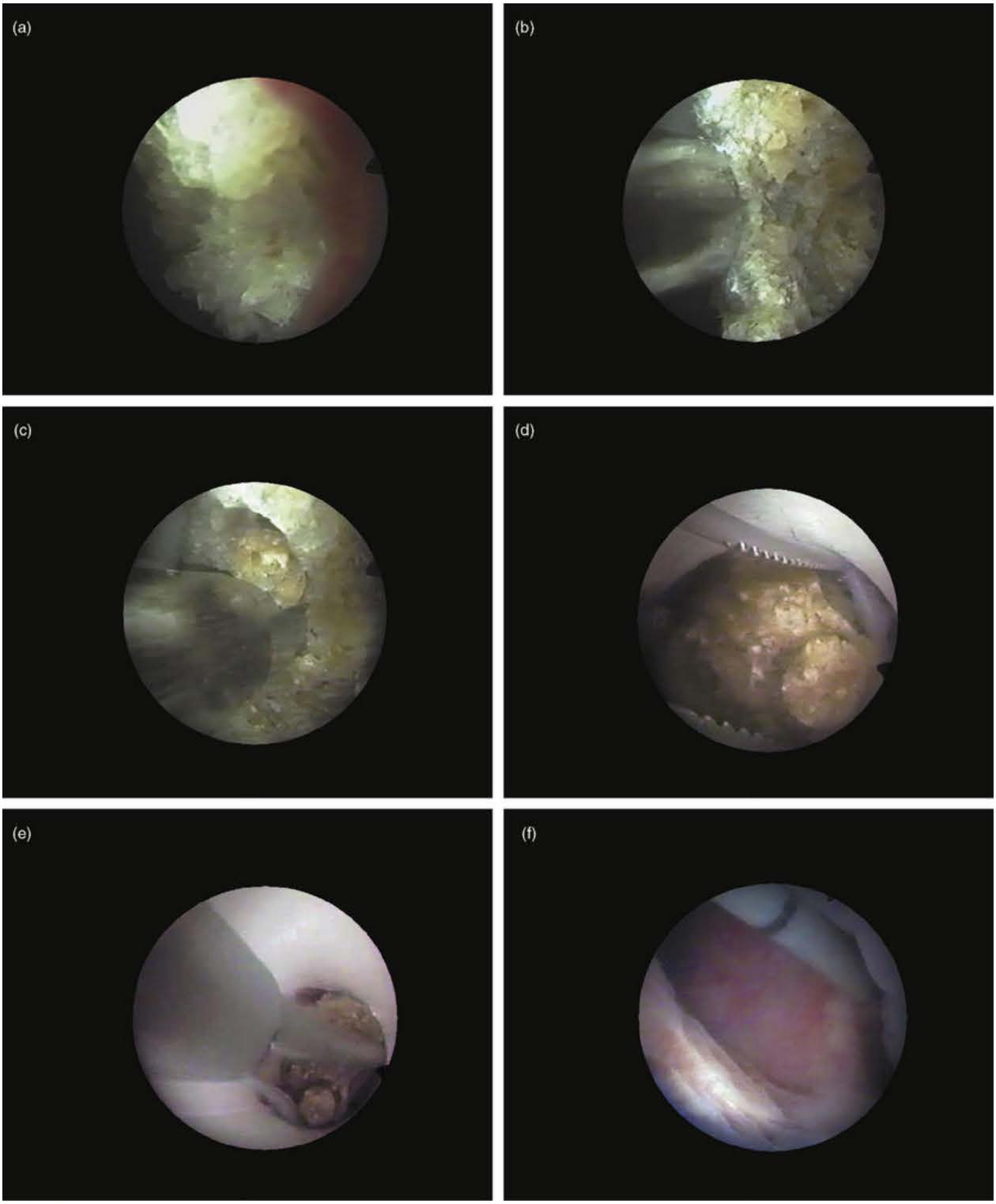

FIGURE 3.46 **Approach of the residual fragments through separate tracts (a), with ultrasonic lithotripsy (b, c), extraction with the tripod grasper (d, e), and final stone-free aspect (f).**

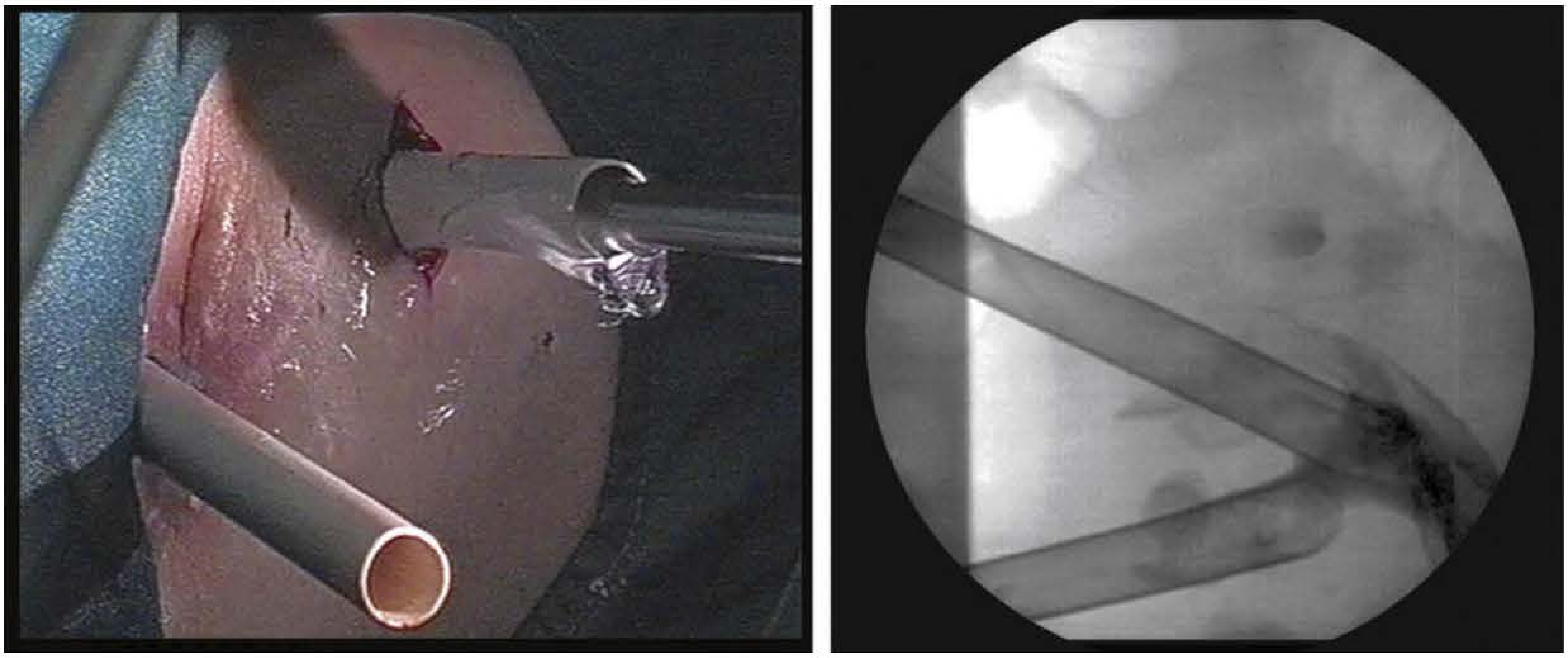

FIGURE 3.47 **Percutaneous approach through two tracts.**

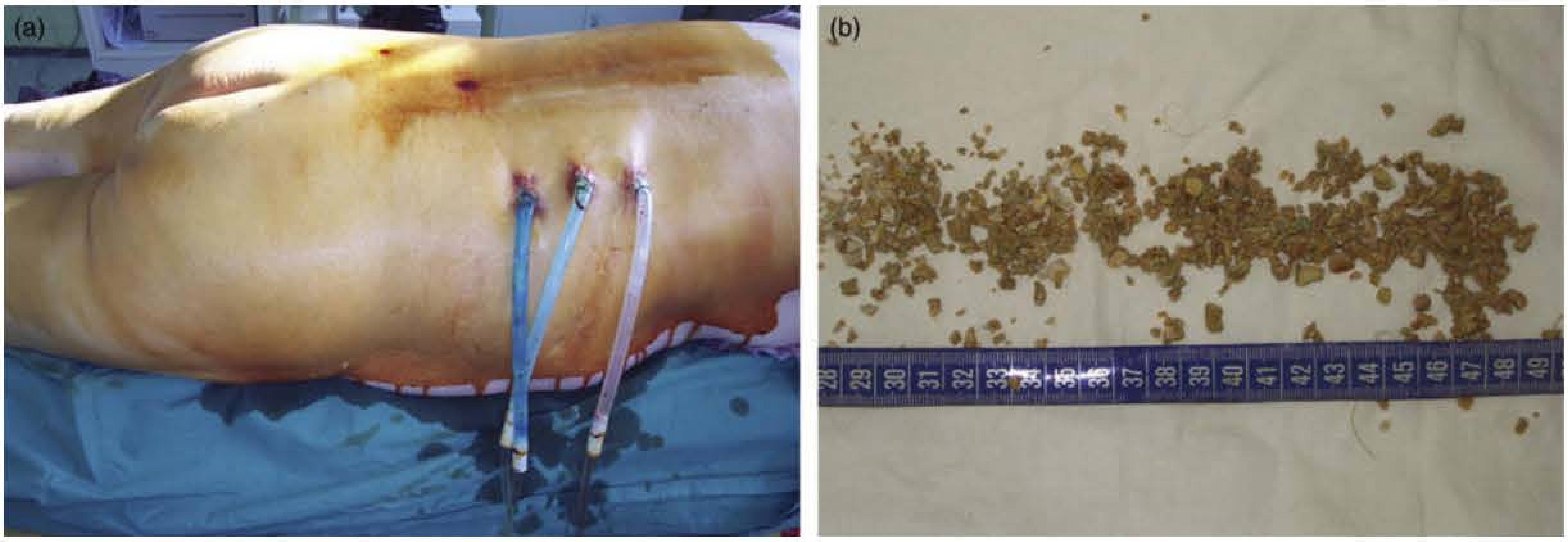

FIGURE 3.48 **Final aspect with three nephrostomy tubes (a) and the lithiasic mass extracted after lithotripsy (b).**

3.11.7 Inspection of the Entire Pyelocaliceal System for Identifying Lithiasic Remnants

Any flexible percutaneous intervention for renal lithiasic pathology should include a retrograde pyelography, associated with systematic inspection of all caliceal groups, of the renal pelvis and of the ureteropelvic junction, in order to check the absence of lithiasic remnants (Davol et al., 2006).

Direct visual inspection of the pyelocaliceal system allows identifying and extracting lithiasic fragments that were not detected by imaging (Figs 3.73–3.79).

3.11.8 Placing the Nephrostomy Tube

Placing the nephrostomy tube represents the last step of most percutaneous interventions. The "tubeless" intervention, without a nephrostomy tube, can end after the second-look flexible nephroscopy.

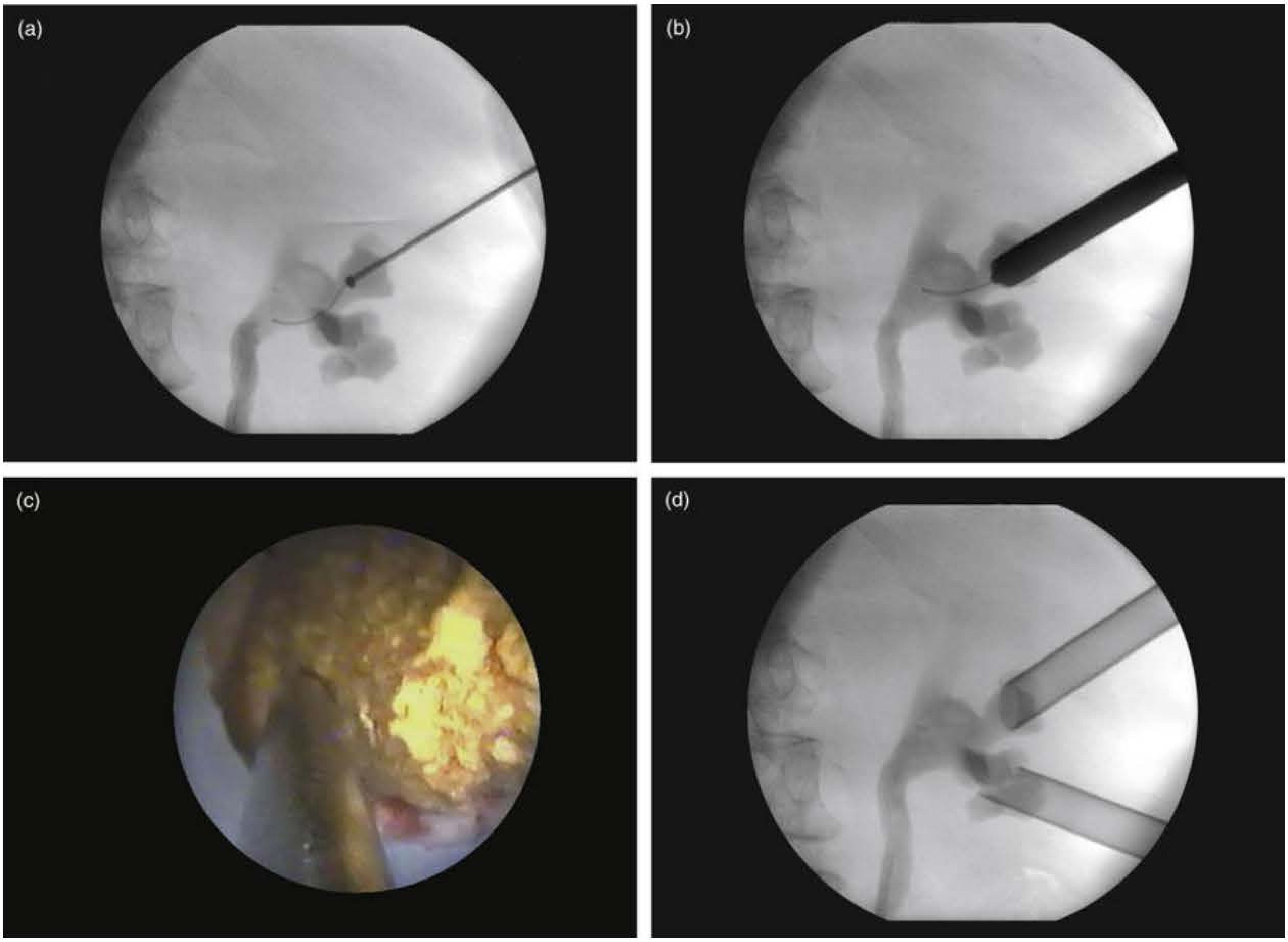

FIGURE 3.49 Middle caliceal percutaneous approach (a, b), with removal of the lithiasis from this level (c), followed by the creation of a new lower caliceal tract and extraction of the stones (d).

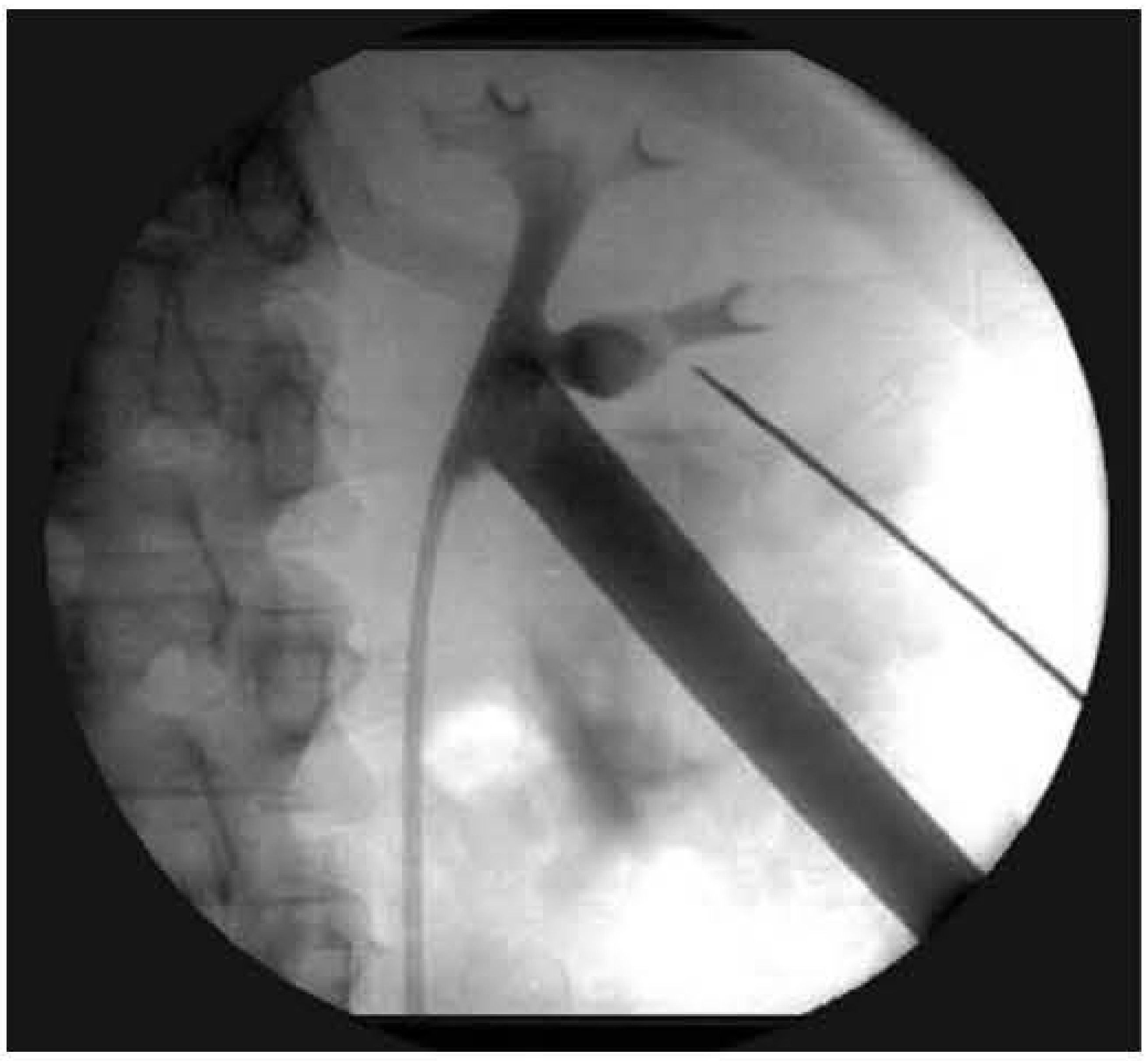

FIGURE 3.50 Pushing a middle caliceal stone with the needle toward the renal pelvis, into an area accessible through the lower caliceal tract.

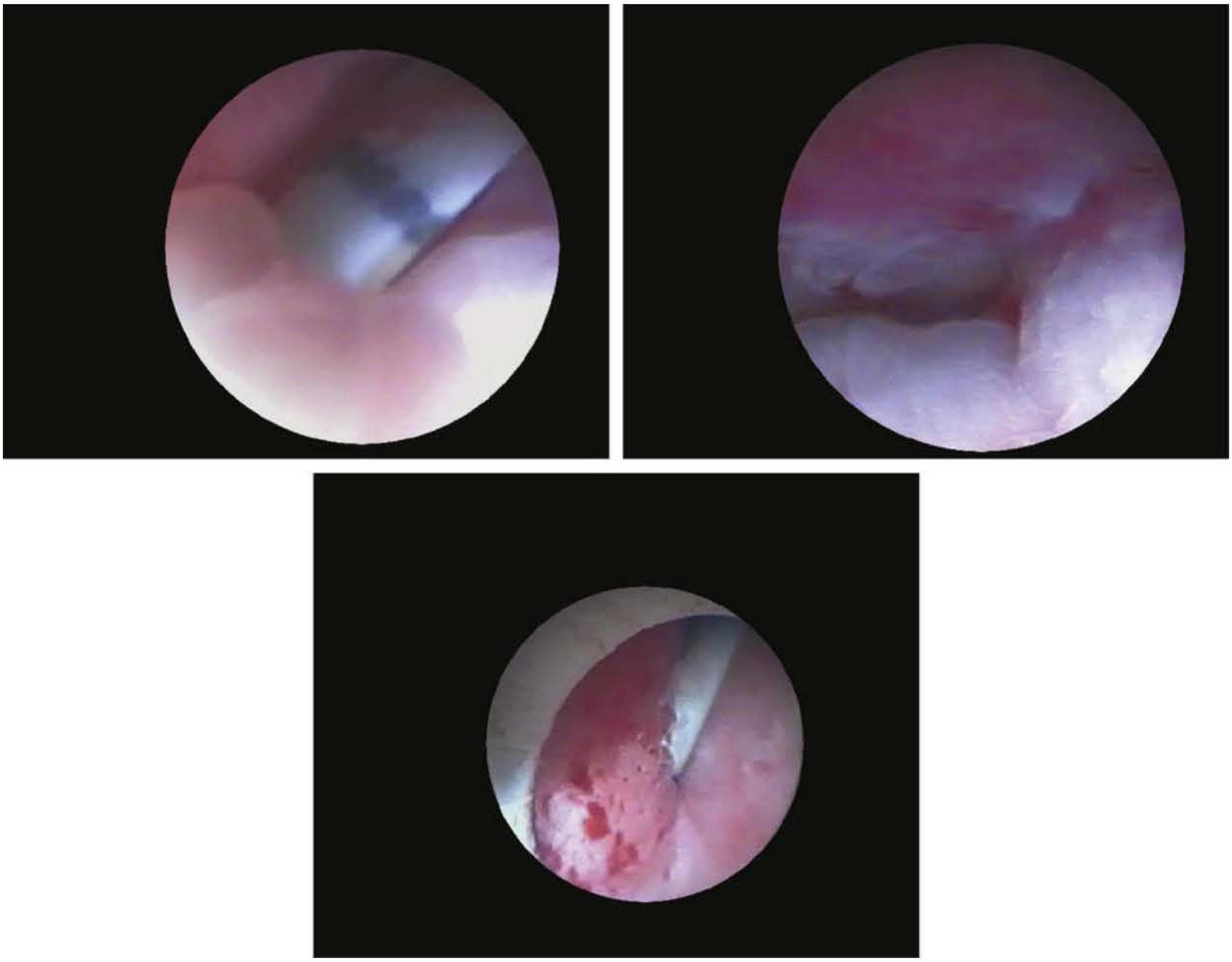

FIGURE 3.51 Checking the stone-free status of the ureteropelvic junction at the end of the intervention.

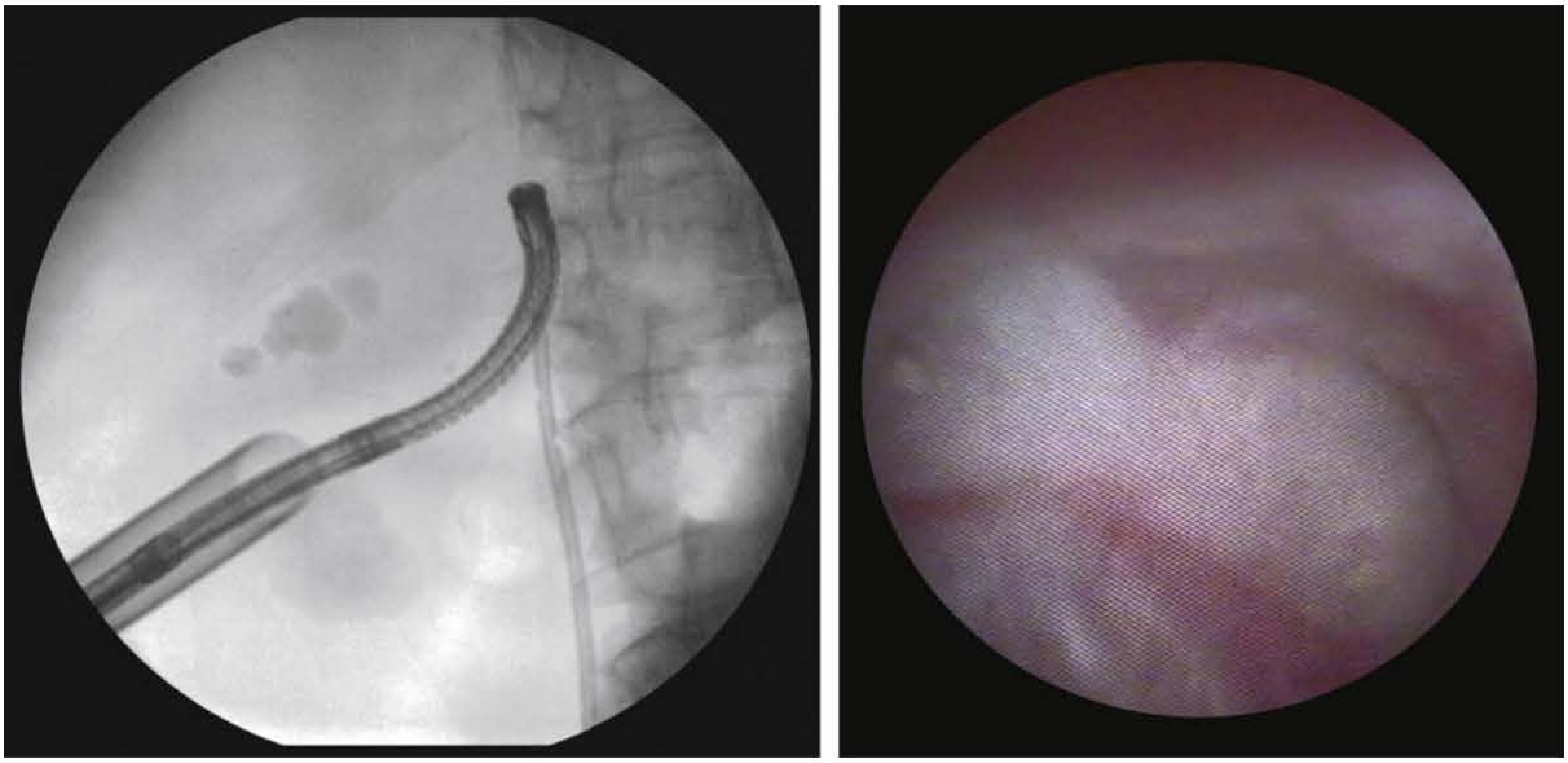

FIGURE 3.52 Inspection of the upper calyx using the flexible nephroscope.

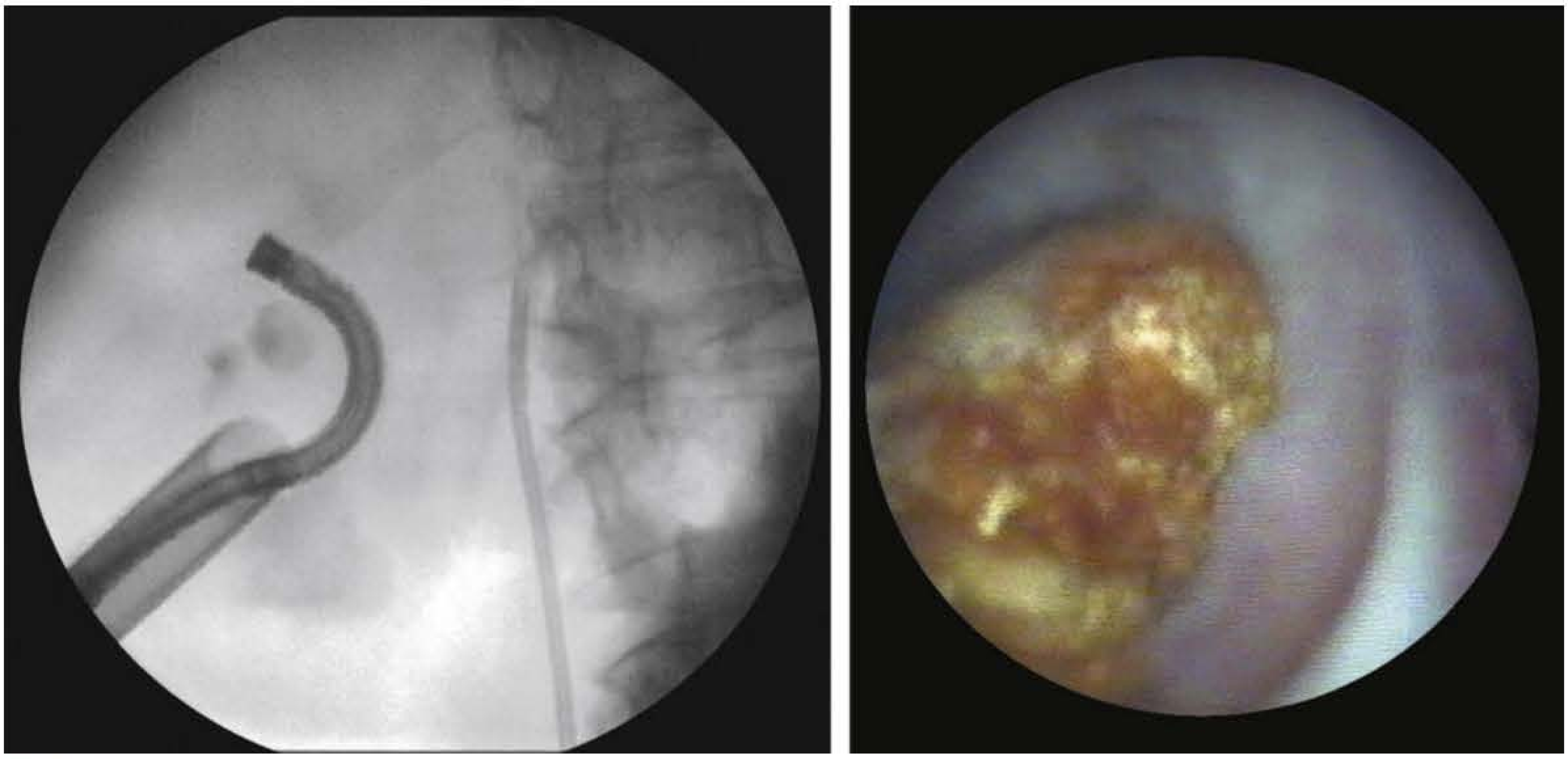

FIGURE 3.53 Inspection of the middle calyx with visualization of the stones at this level.

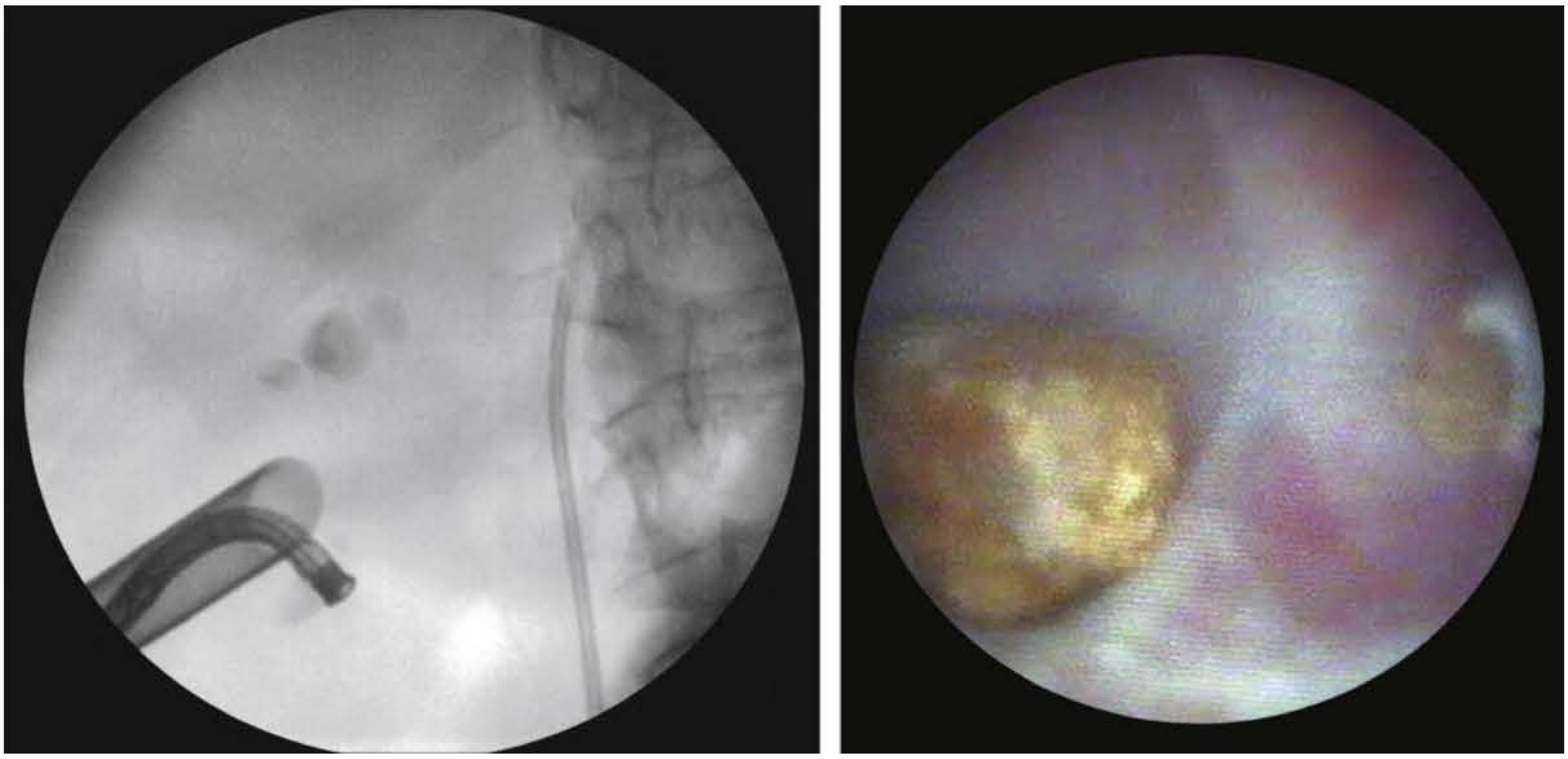

FIGURE 3.54 Inspection of a lower secondary calyx with visualization of the stone at this level.

3.12 PARTICULAR SITUATIONS

3.12.1 Soft Lithiasis

A particular situation is represented by soft lithiasis (matrix lithiasis), which is very difficult and laborious to extract with instruments created for tough stone fragments (Fig. 3.80).

Very often, the fragility of the soft amorphous mass makes it impossible to remove a large amount during a single excursion of the endoscope, greatly prolonging the intervention. The situation is further complicated by the presence of this type of lithiasis, most frequently in a large amount, even determining type A staghorn calculi (Fig. 3.81).

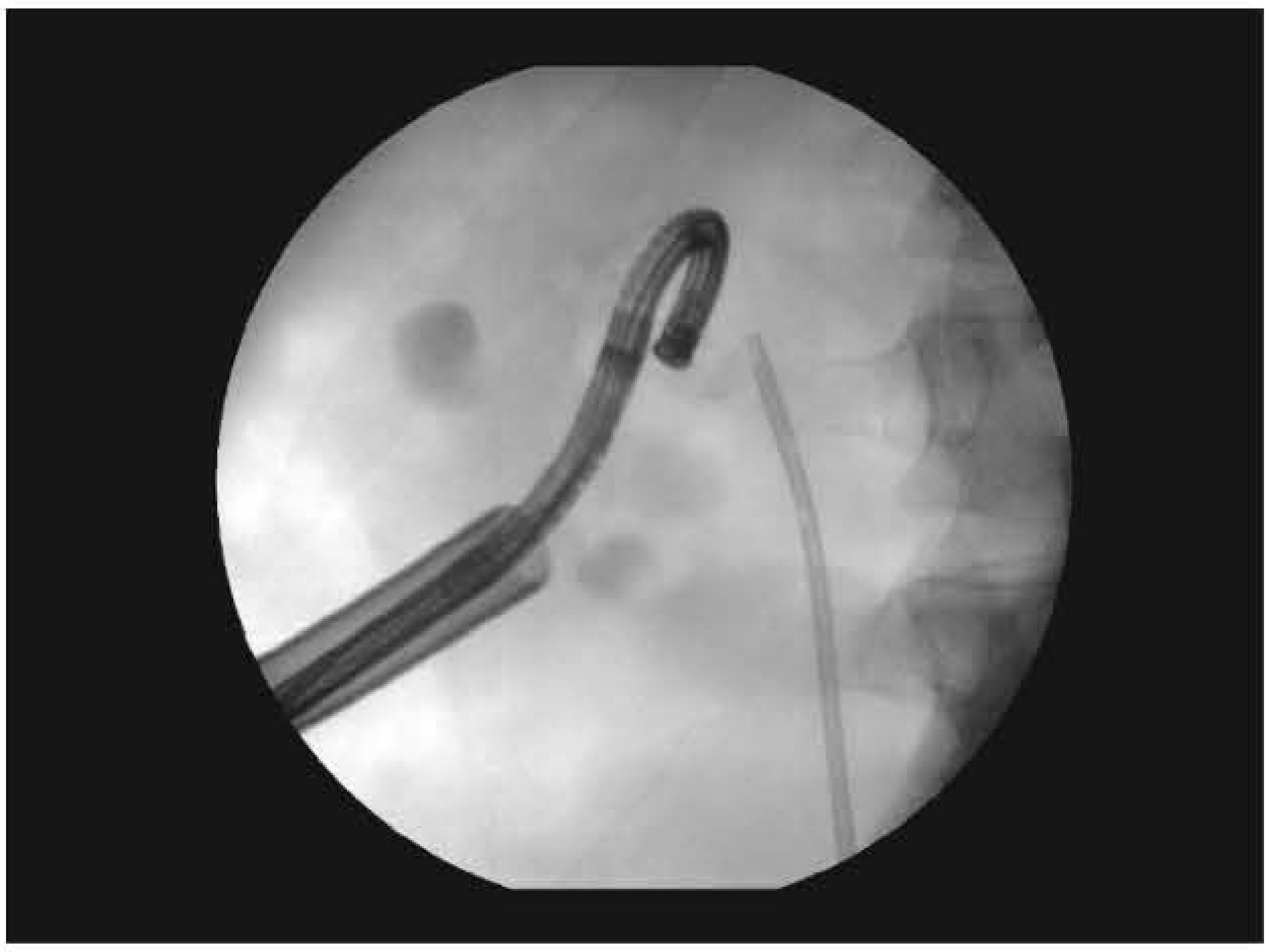

FIGURE 3.55 Flexible nephroscopic approach of a stone located in an anterior secondary middle calyx.

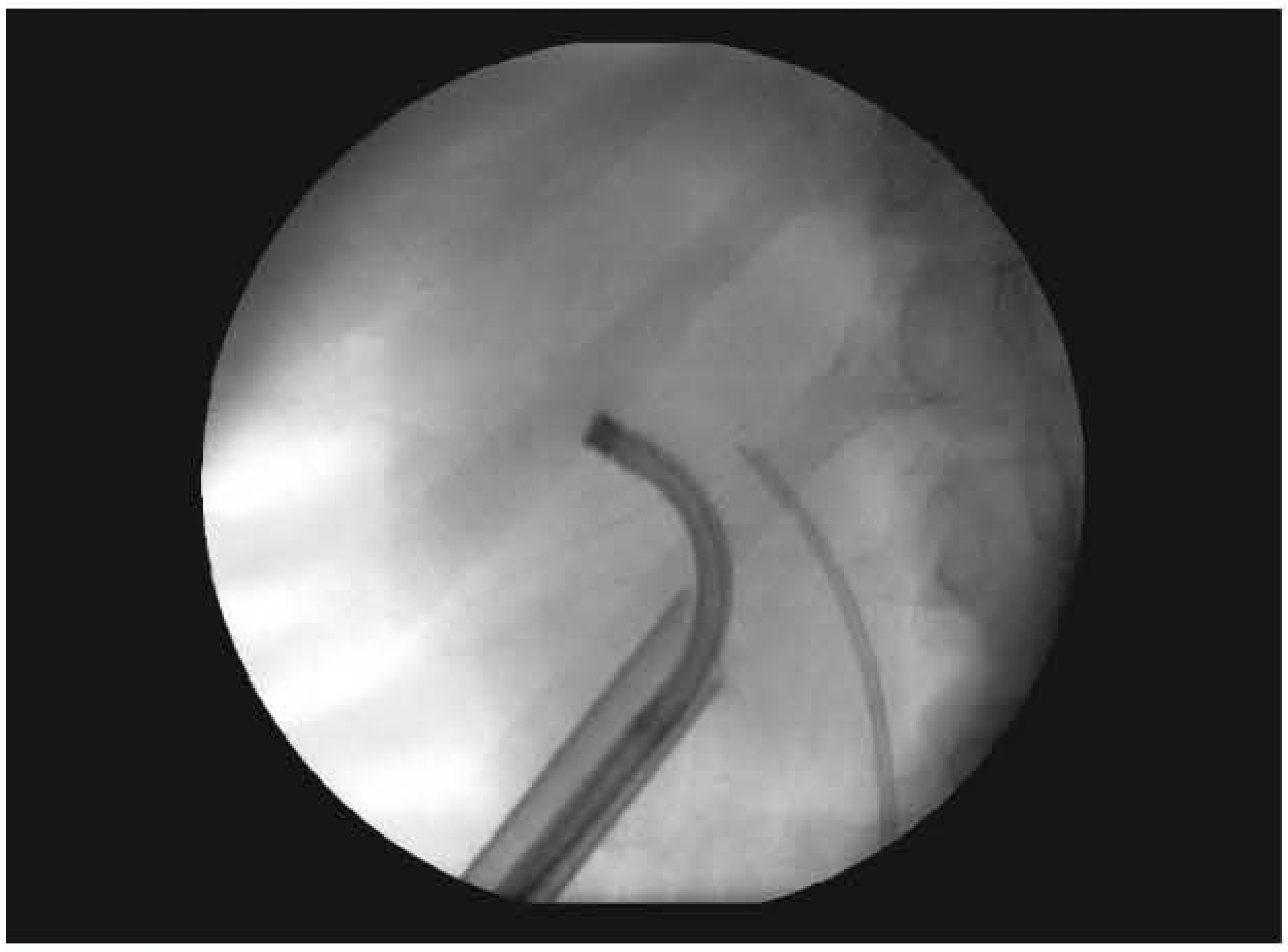

FIGURE 3.56 Flexible nephroscopic approach of the upper calyx.

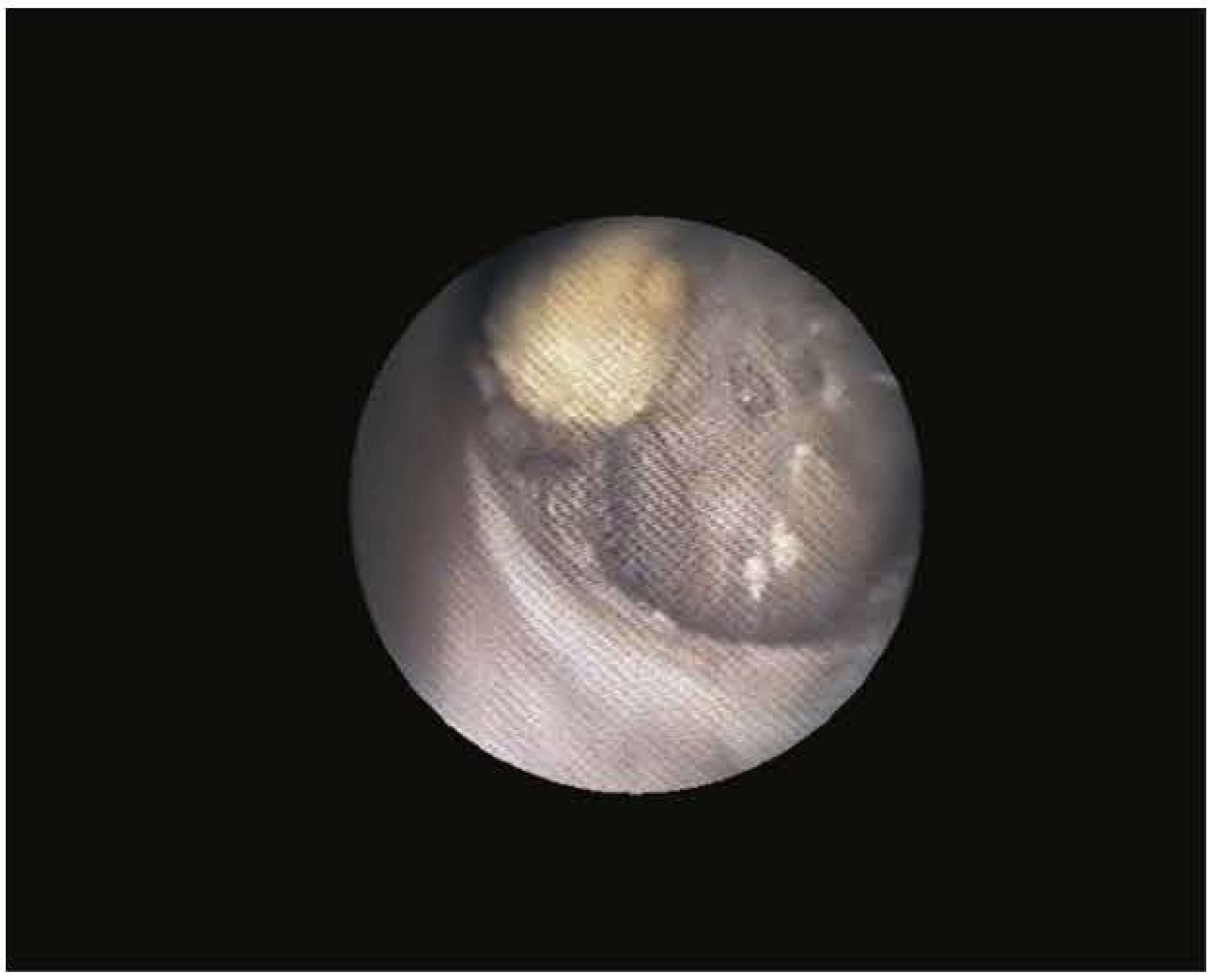

FIGURE 3.57 Upper caliceal stone.

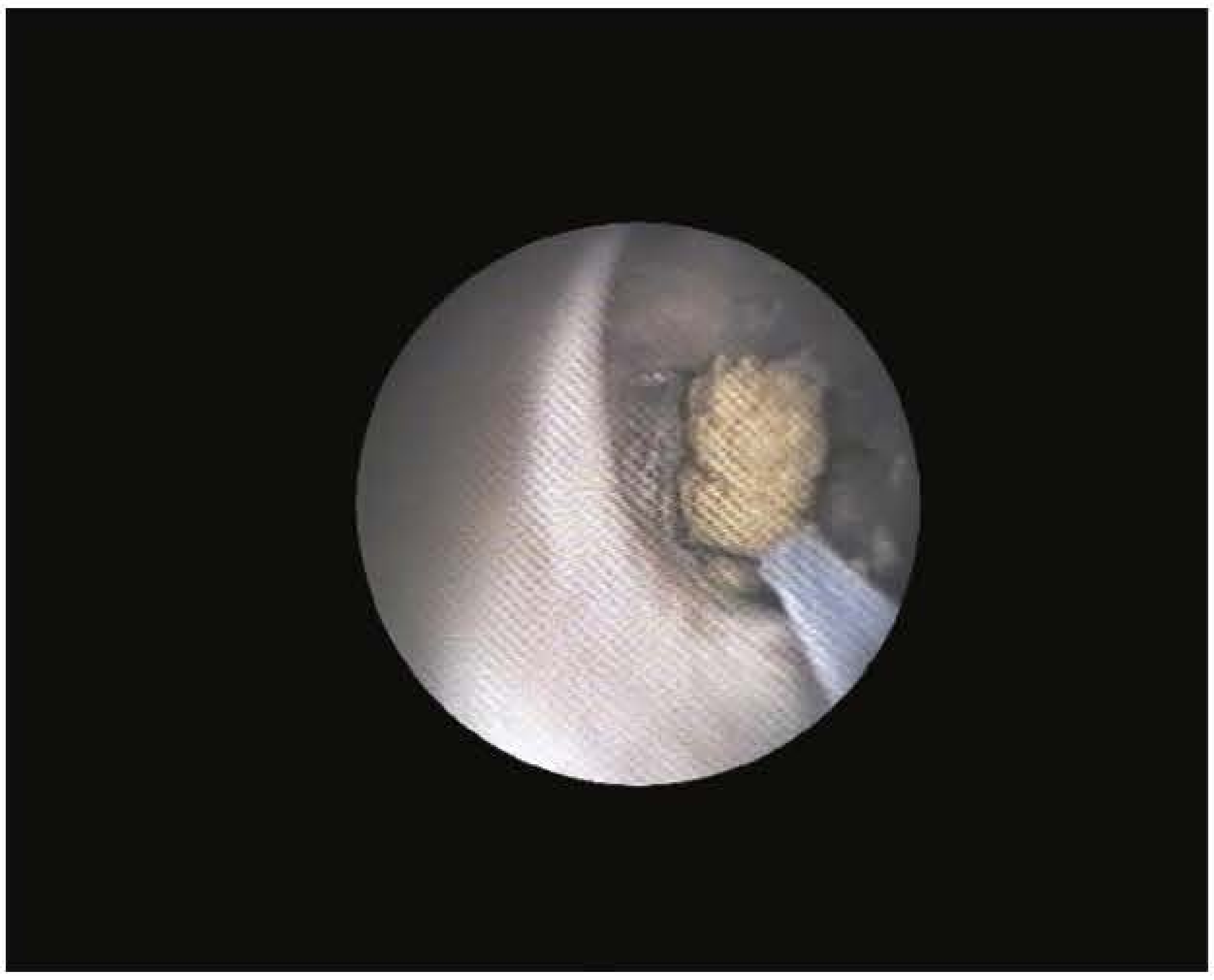

FIGURE 3.58 Extraction of the upper caliceal stone with the tripod forceps inserted through the flexible nephroscope.

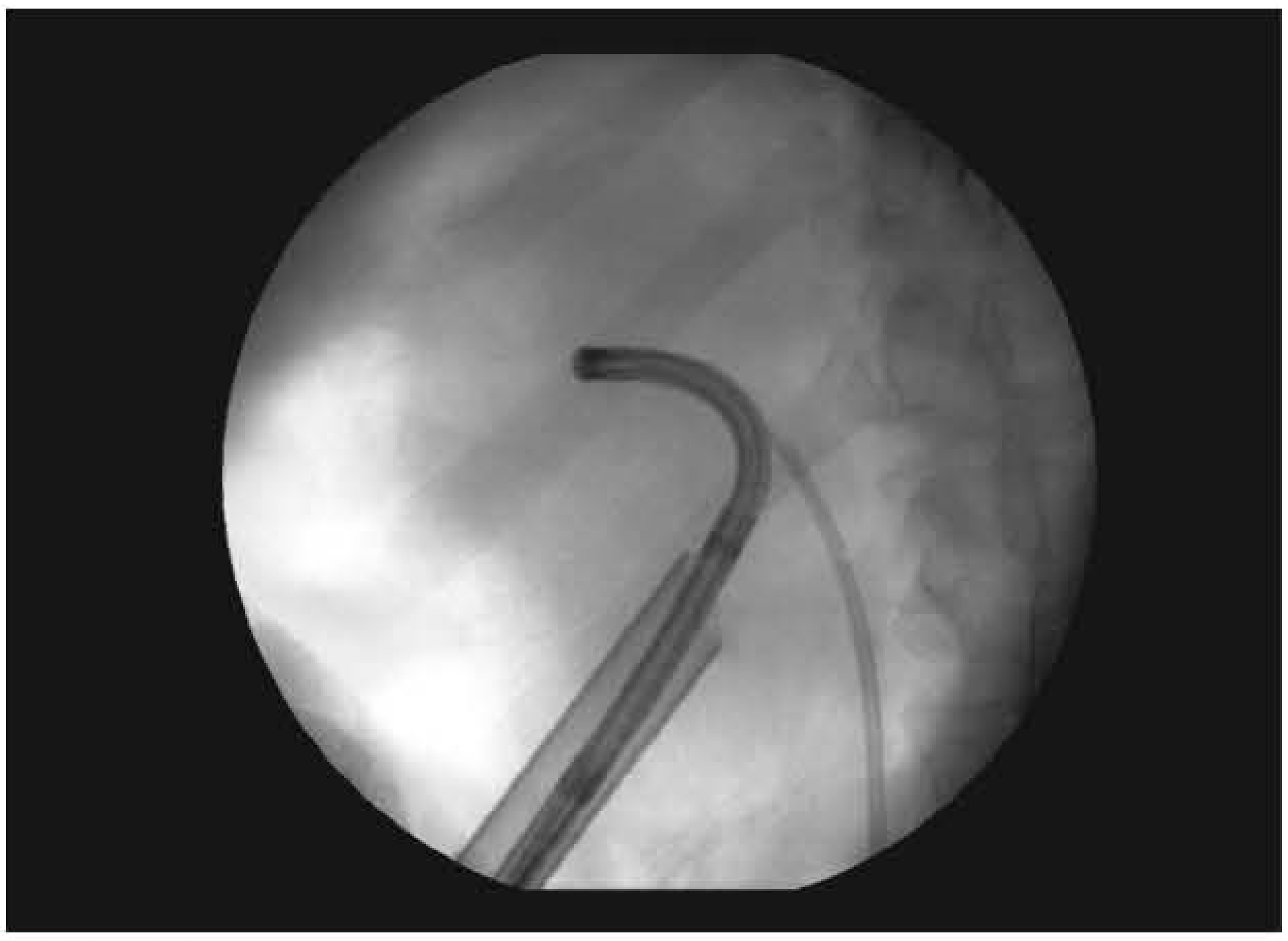

FIGURE 3.59 Flexible nephroscopic approach of the middle calyx.

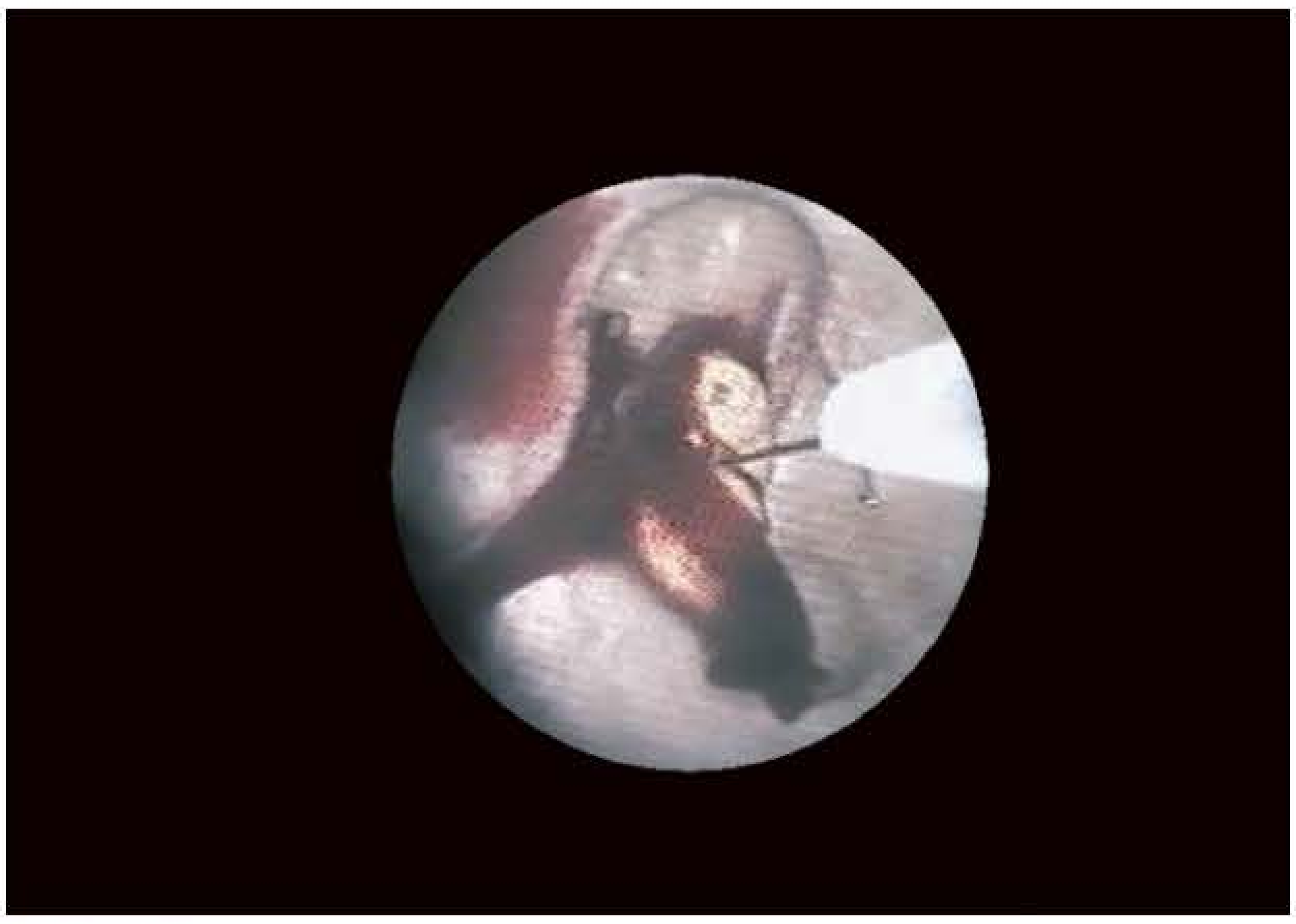

FIGURE 3.60 Extraction of the middle caliceal stones with the tripod forceps inserted through the flexible nephroscope.

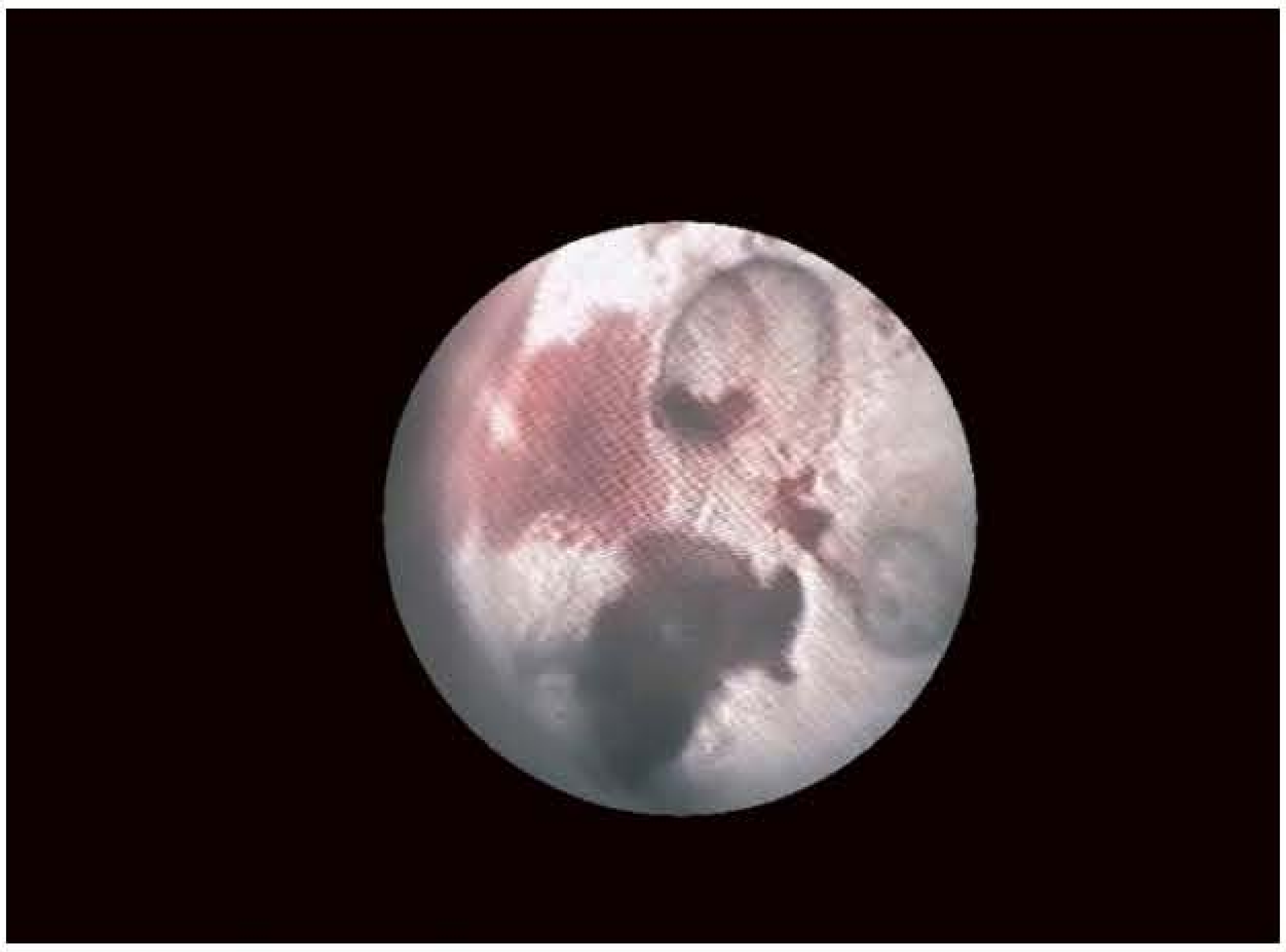

FIGURE 3.61 Stone-free aspect of the middle calyx.

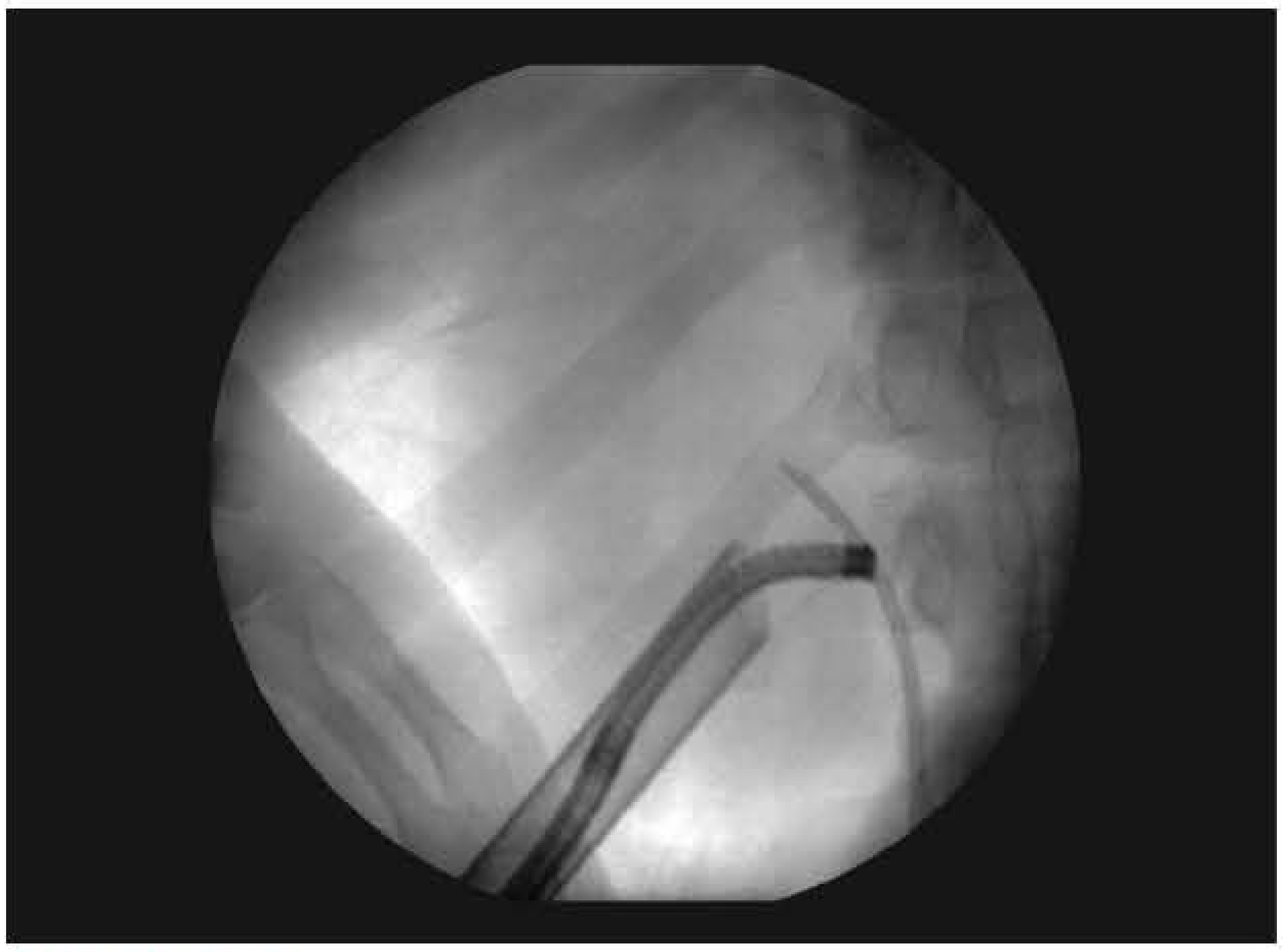

FIGURE 3.62 Inspection of the pyeloureteral junction using the flexible nephroscope.

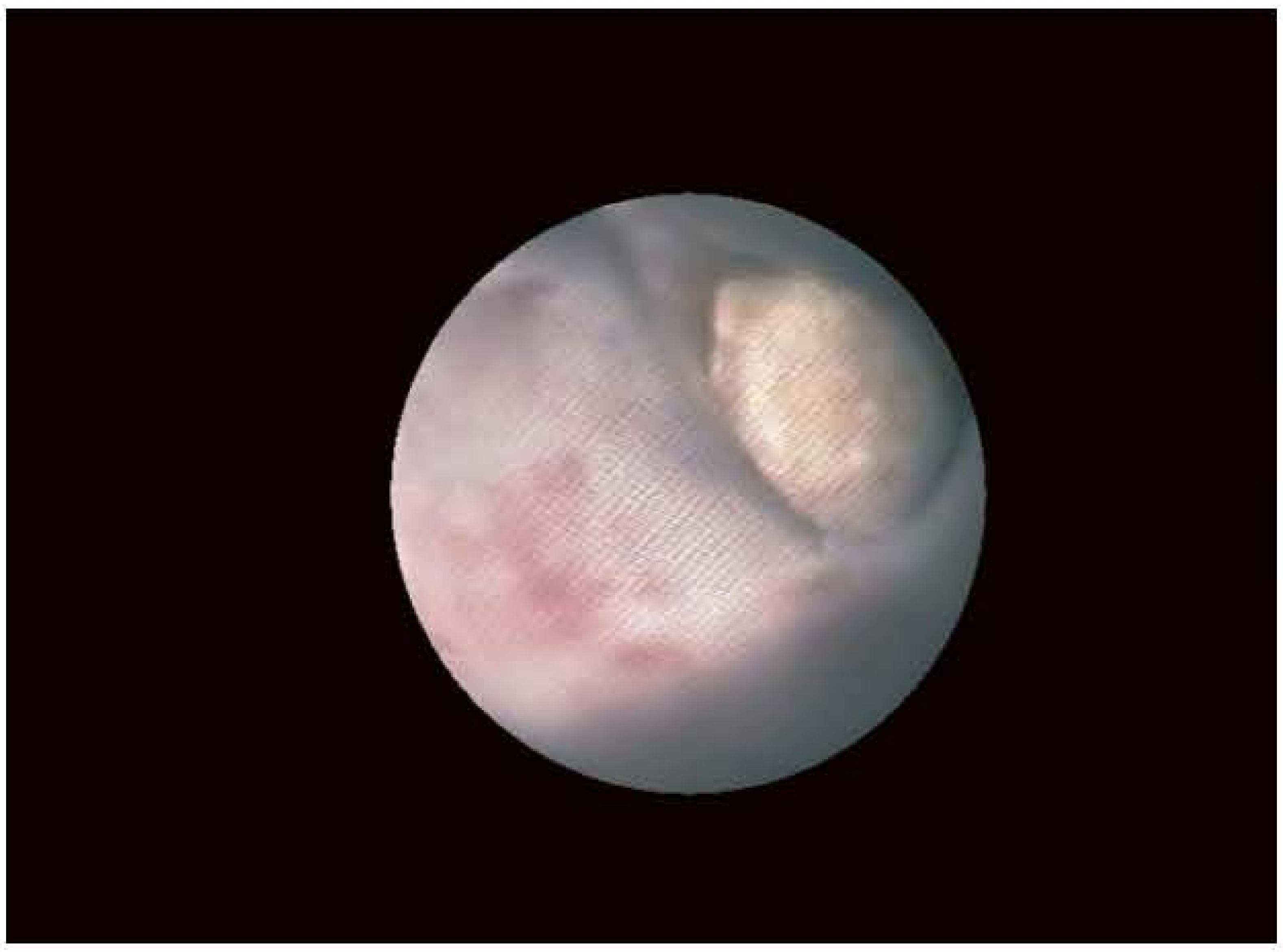

FIGURE 3.63 Extraction of a stone from the ureteropelvic junction level using the basket catheter.

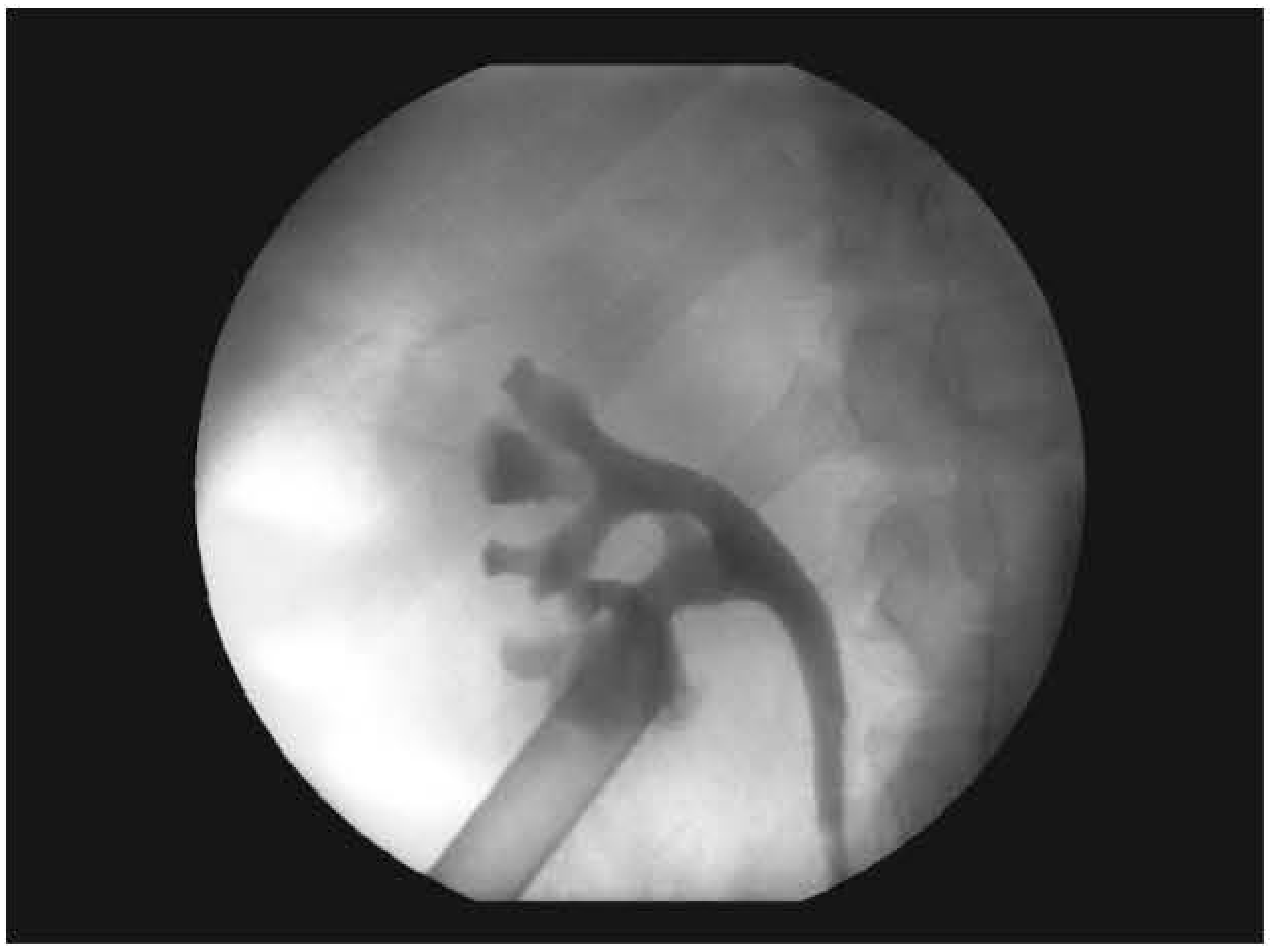

FIGURE 3.64 Stone-free aspect at the end of the intervention.

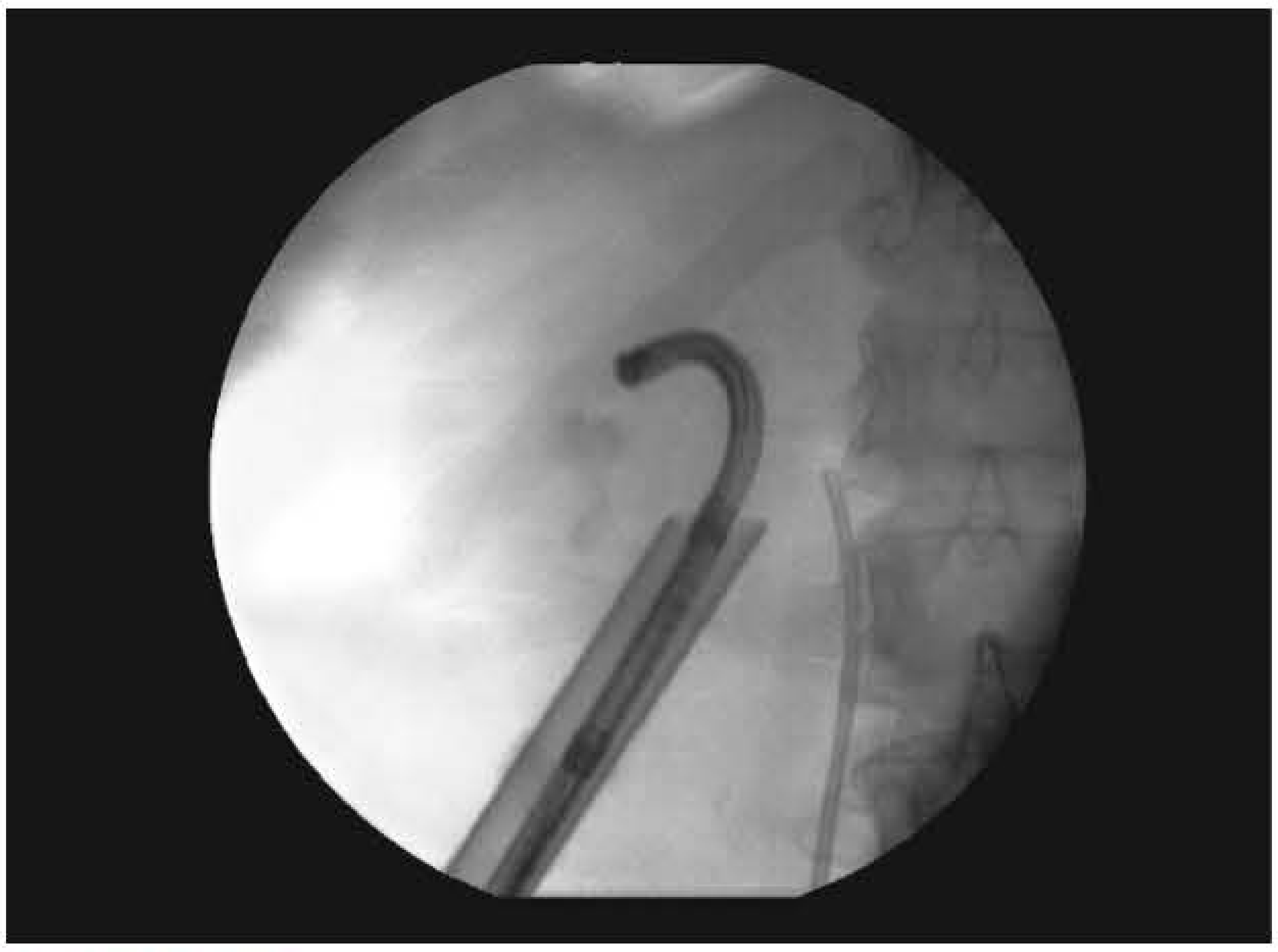

FIGURE 3.65 Flexible nephroscopic approach of a middle caliceal stone (fluoroscopic aspect).

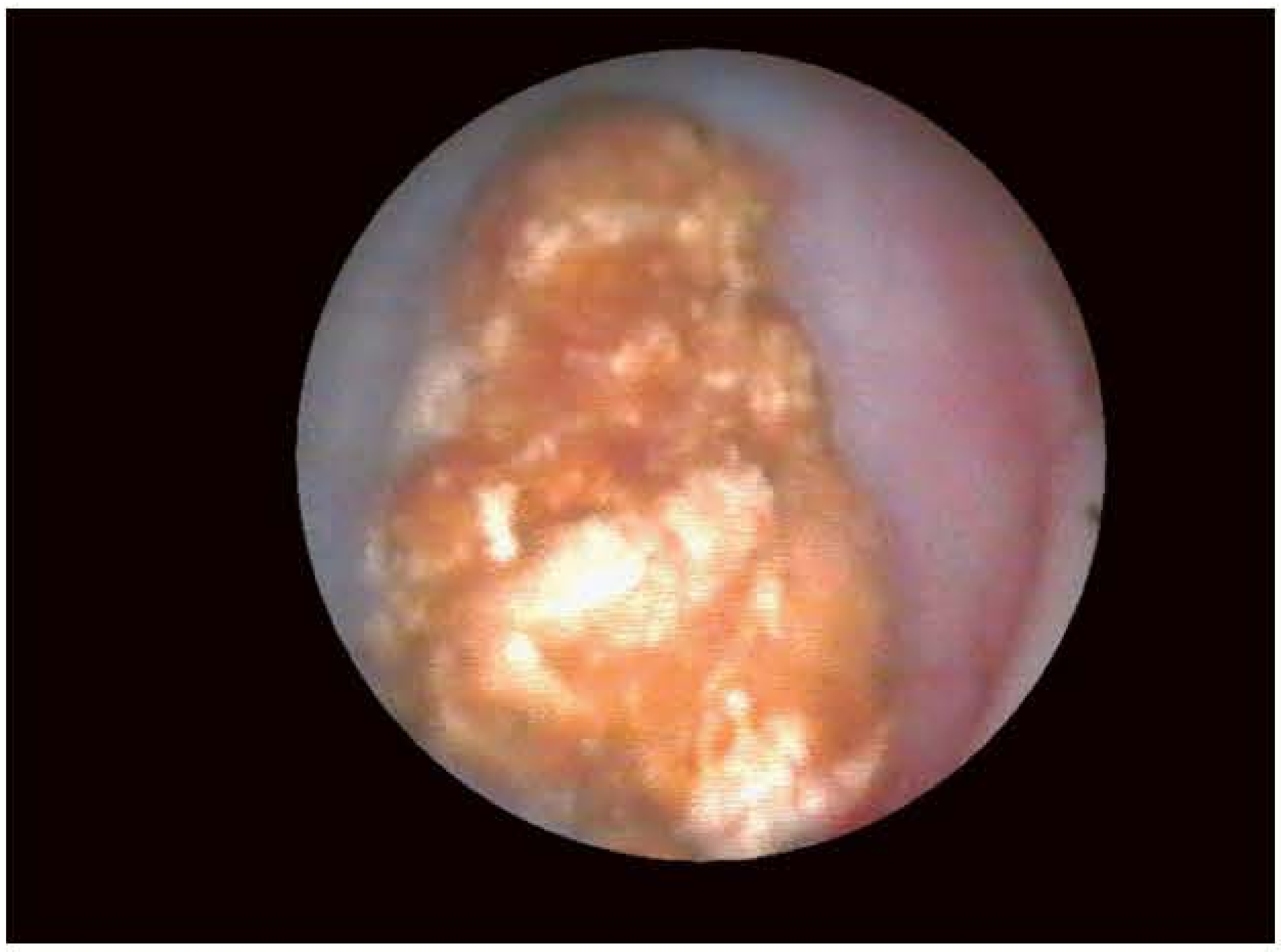

FIGURE 3.66 Flexible nephroscopic approach of a middle caliceal stone (endoscopic aspect).

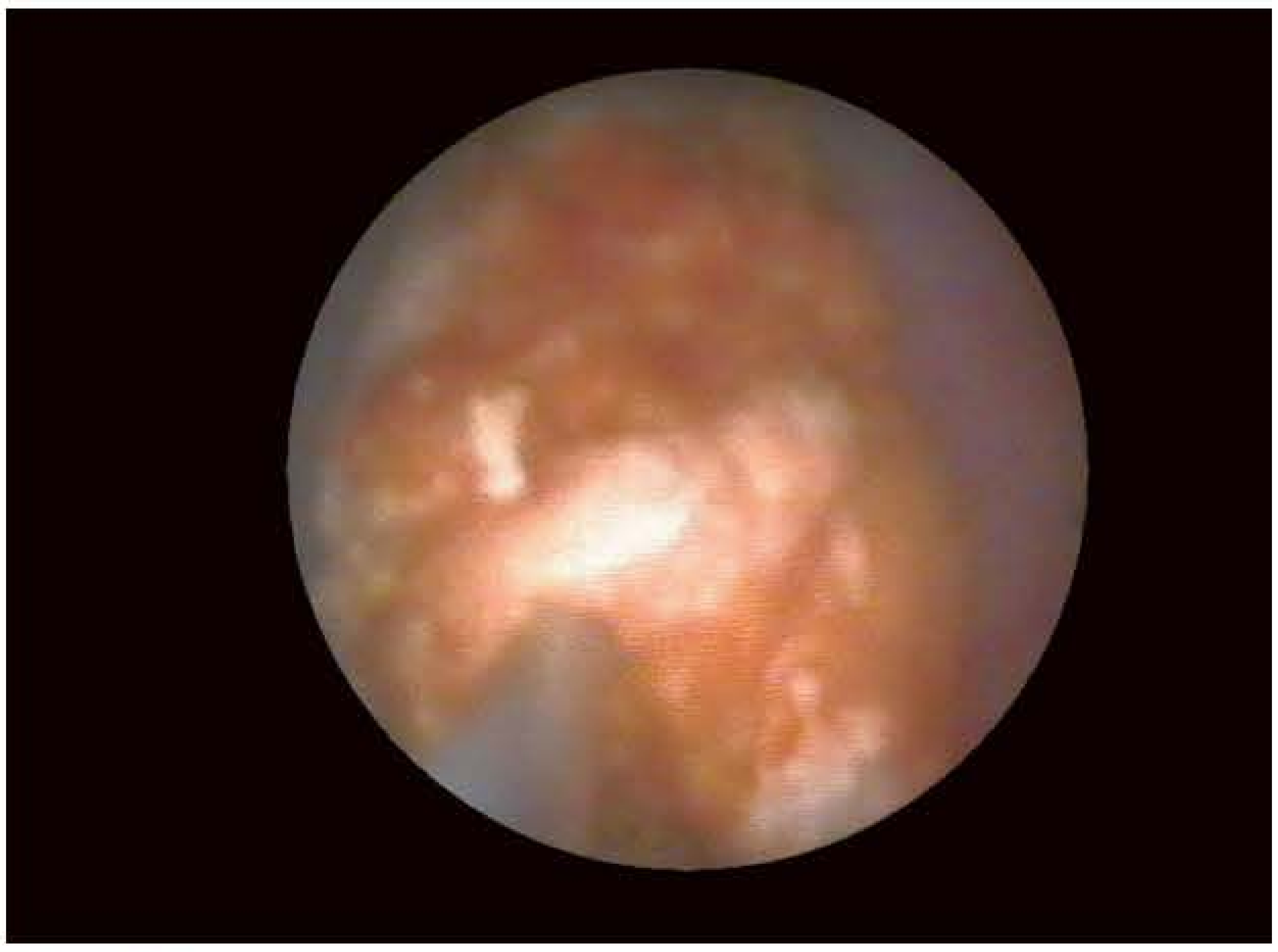

FIGURE 3.67 Electrohydraulic lithotripsy of a middle caliceal stone.

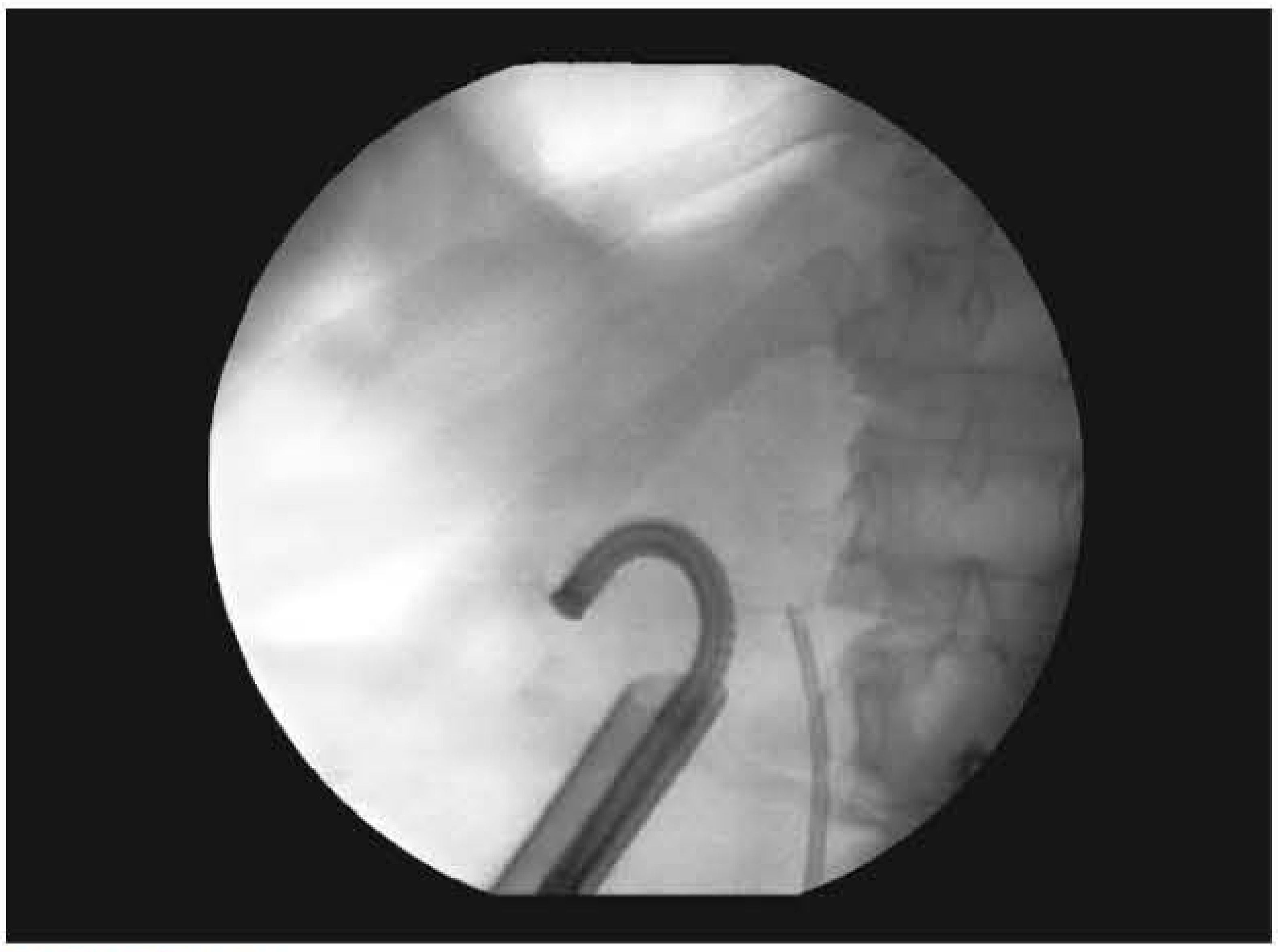

FIGURE 3.68 Partial fragmentation of the stone.

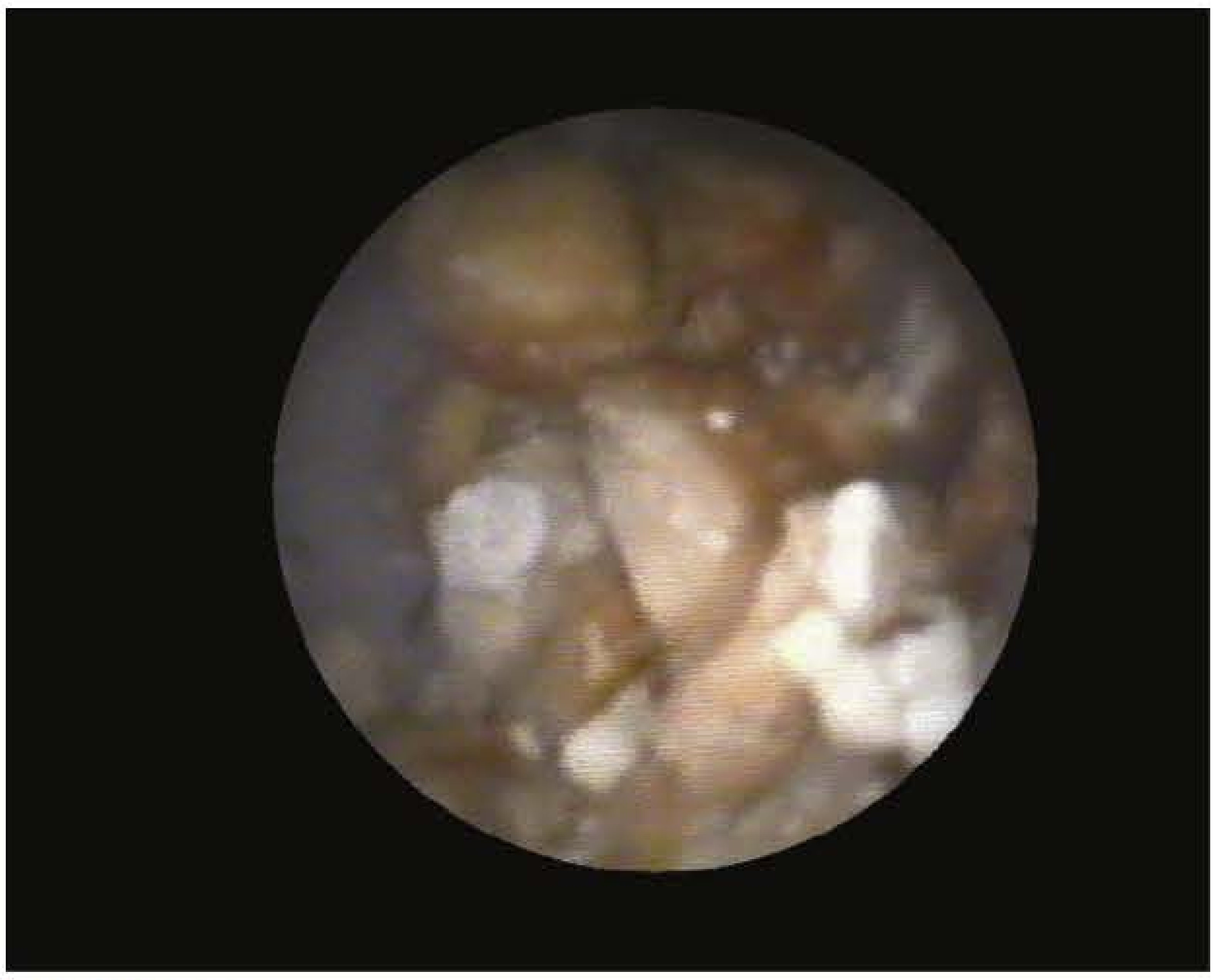

FIGURE 3.69 Lithiasic fragments resulting after electrohydraulic lithotripsy.

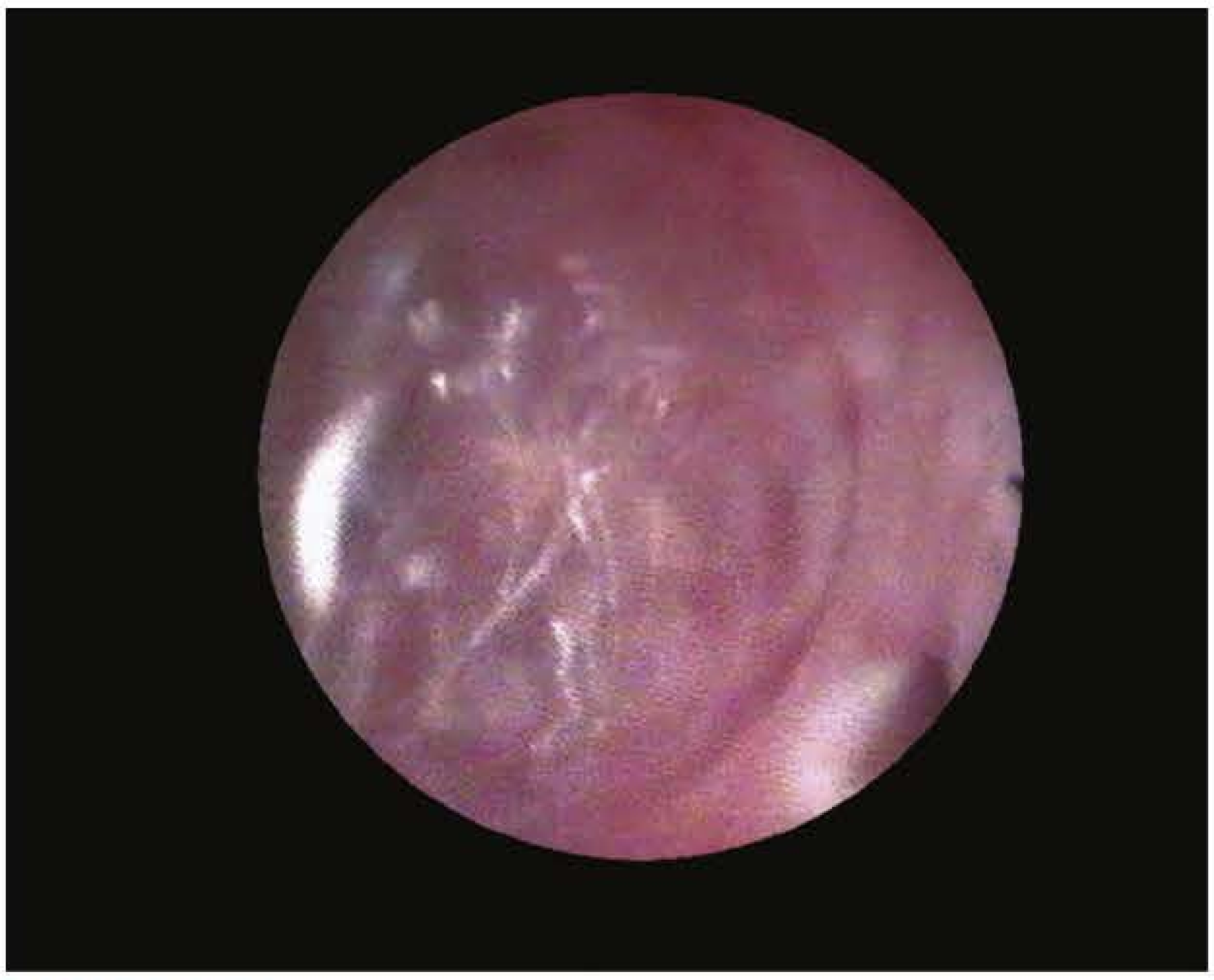

FIGURE 3.70 Stone-free middle calyx.

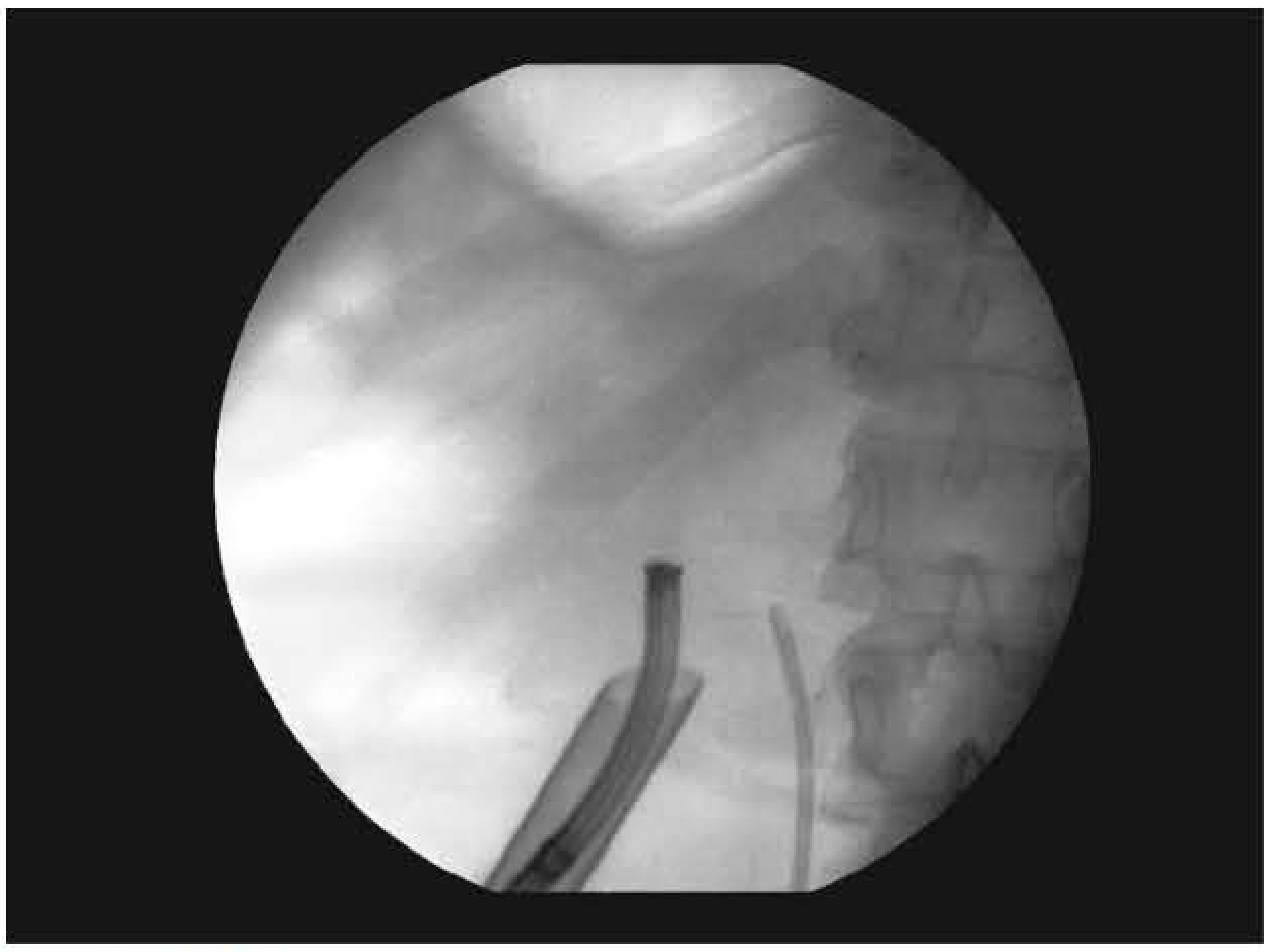

FIGURE 3.71 Stone-free aspect at the end of the intervention.

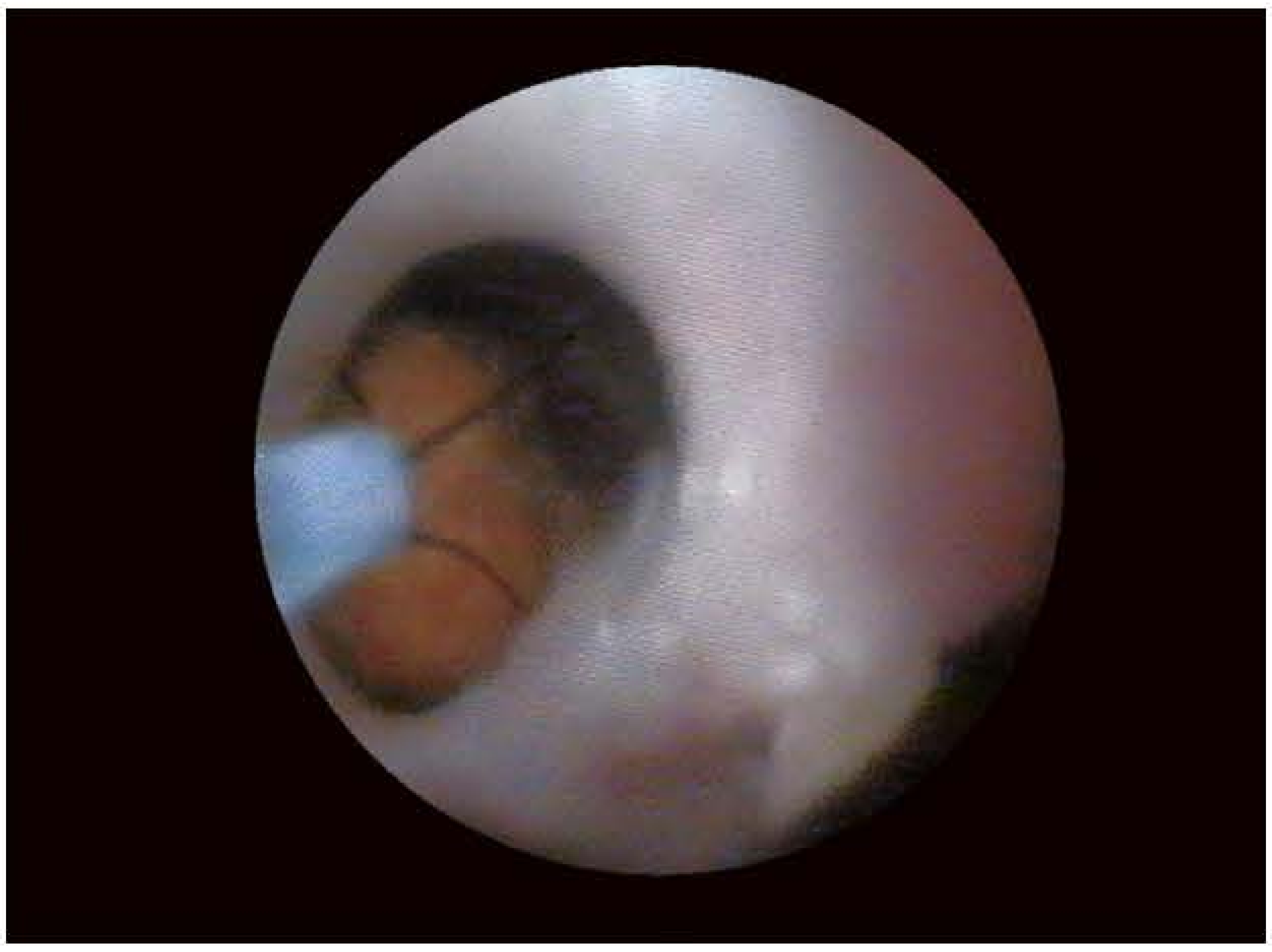

FIGURE 3.72 Extraction of a voluminous lithiasic fragment using the tripod forceps.

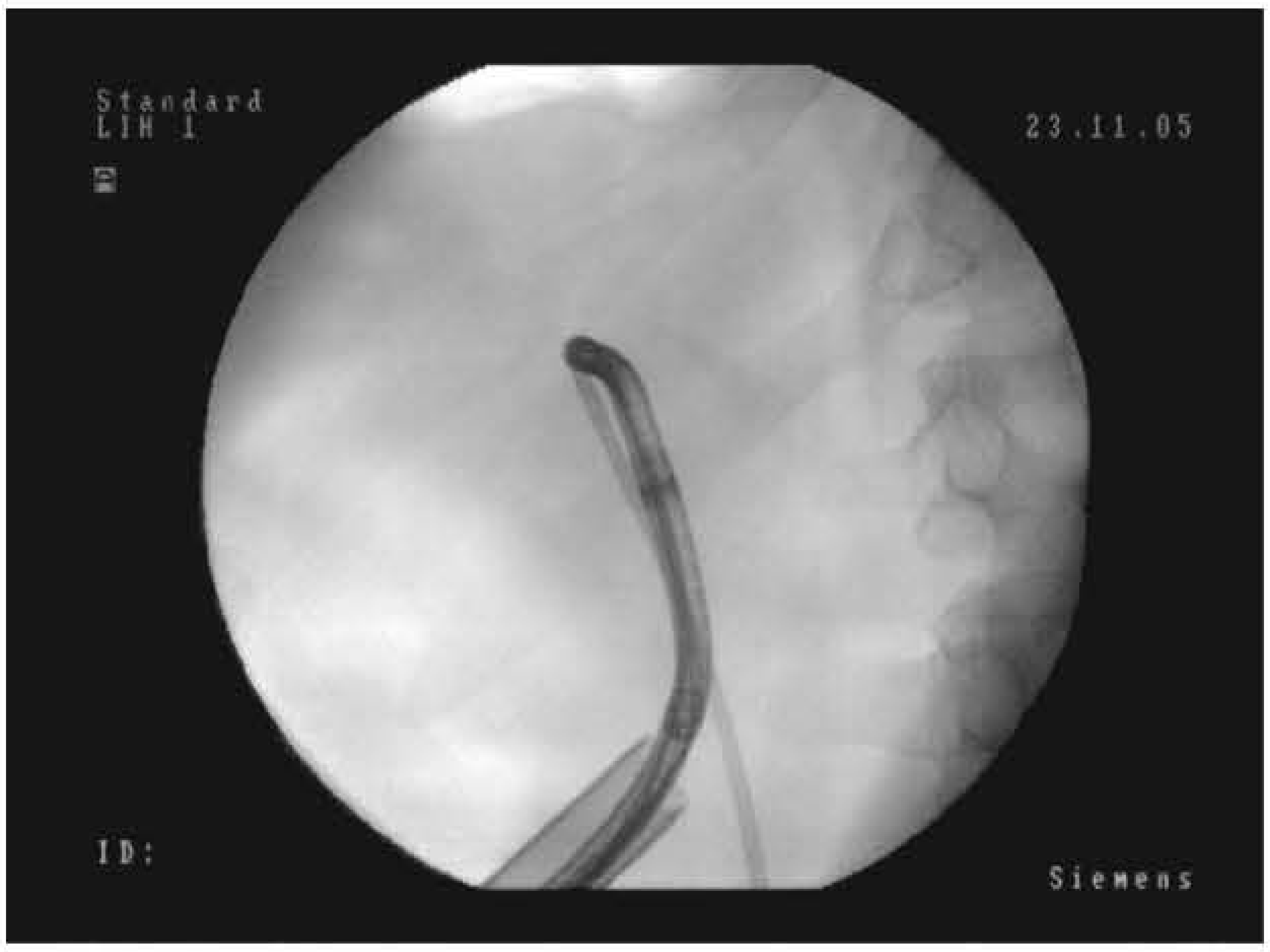
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FIGURE 3.73 Inspection of the upper calyx using the flexible nephroscope.

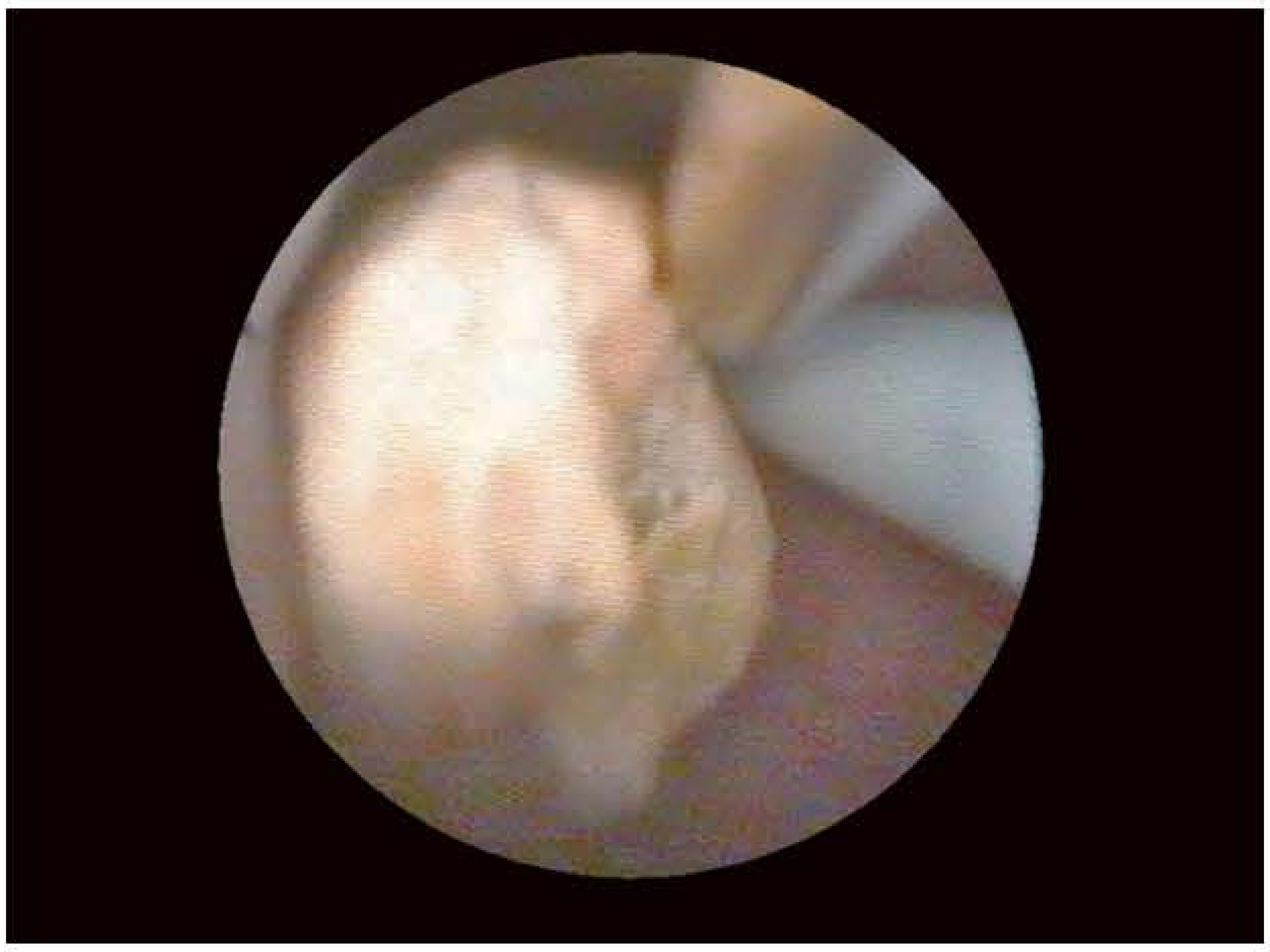

FIGURE 3.74 Radiotransparent upper caliceal lithiasic remnant.

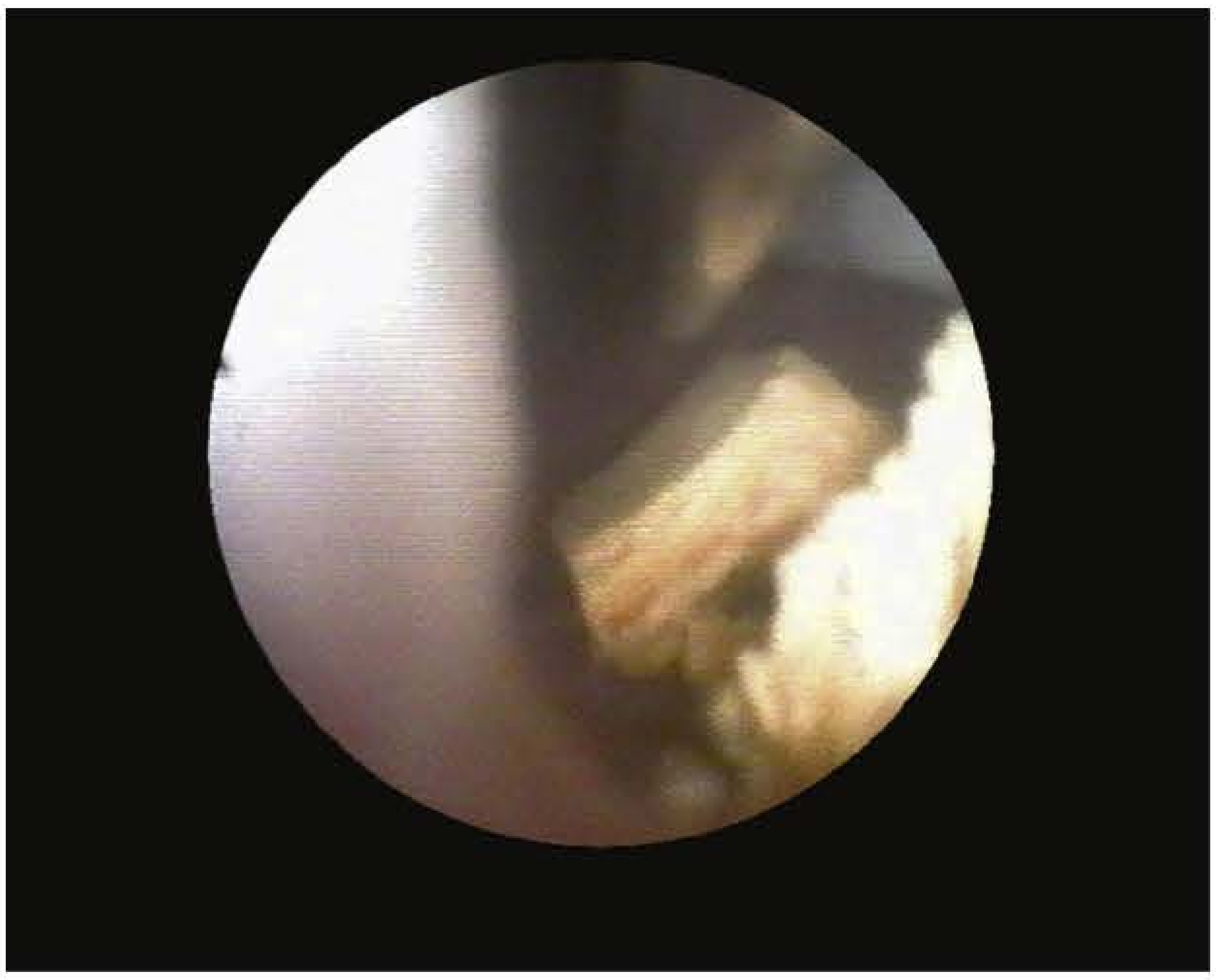

FIGURE 3.75 Electrohydraulic lithotripsy of the upper caliceal stone.

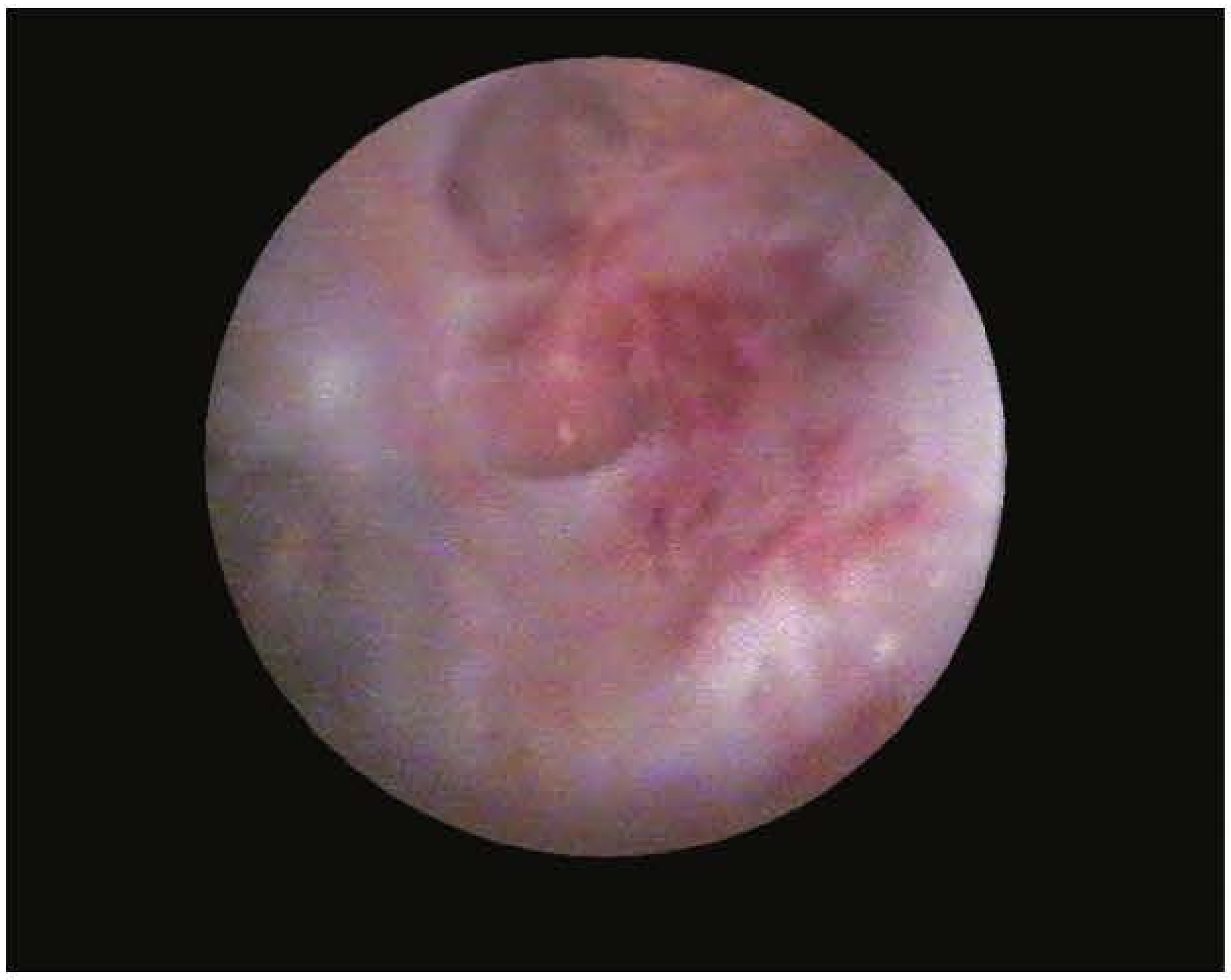

FIGURE 3.76 Stone-free upper calyx after extracting the lithiasic fragments.

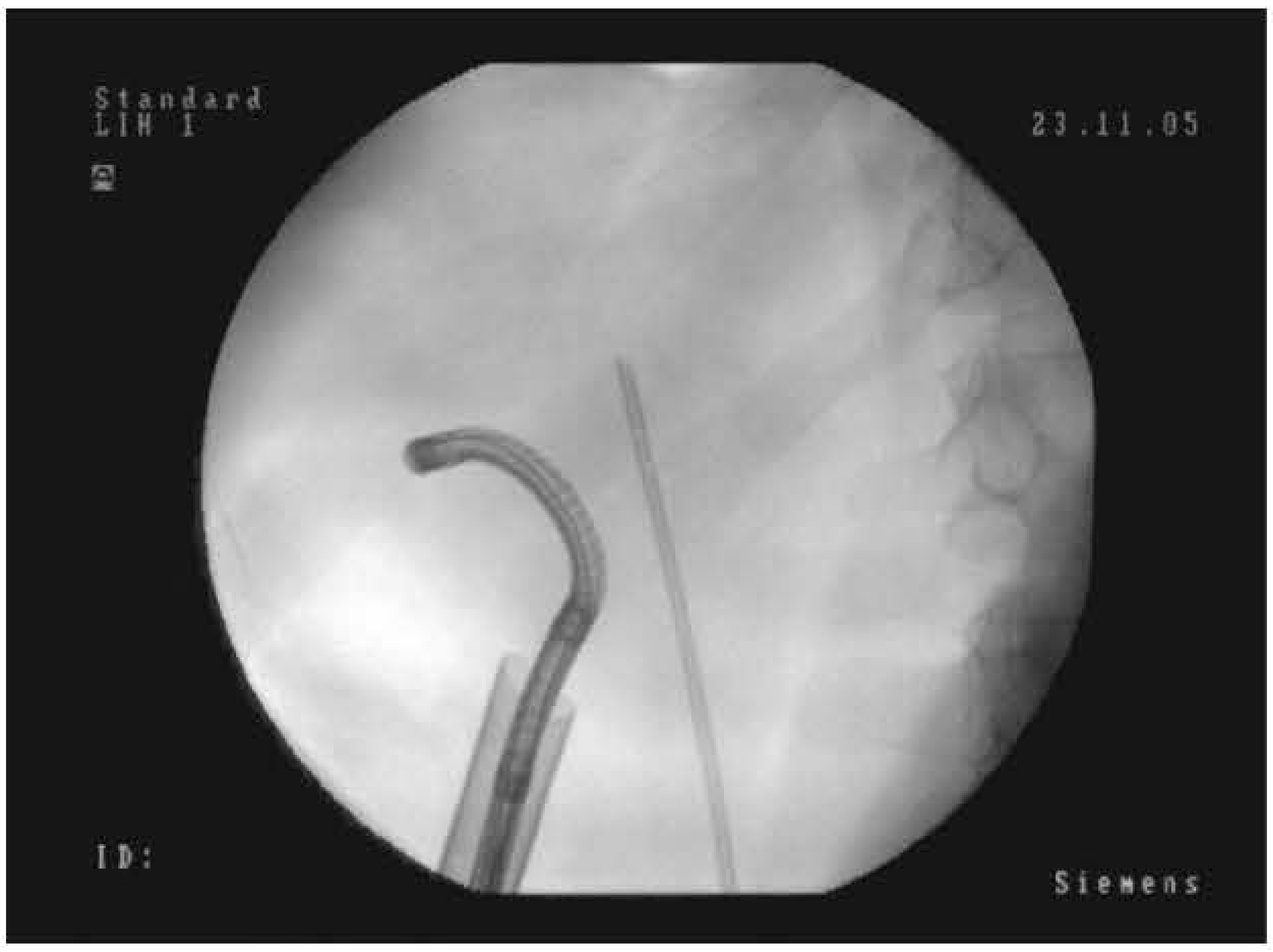
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FIGURE 3.77 Inspection of the middle calyx using the flexible nephroscope.

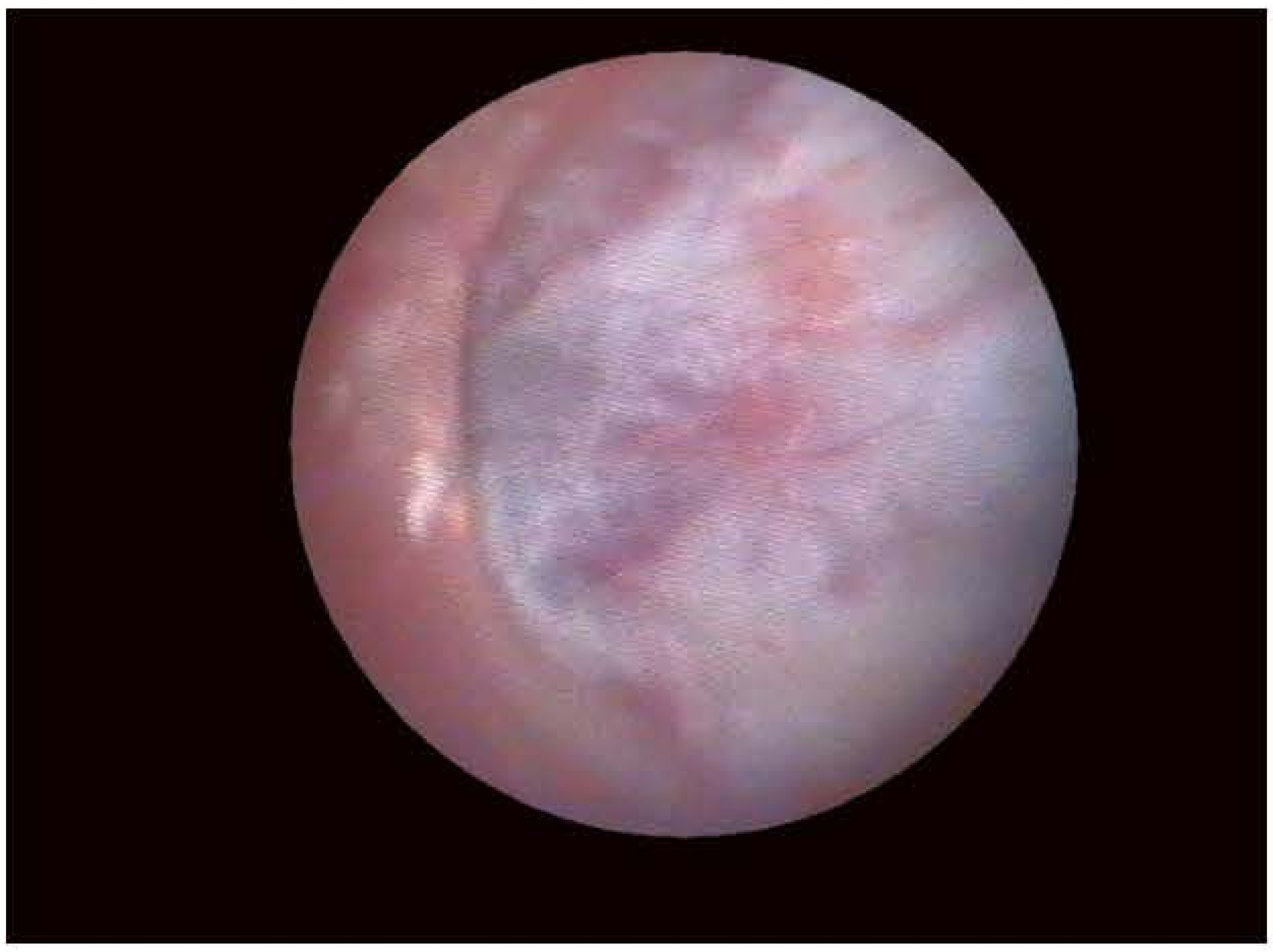

FIGURE 3.78 Middle calyx without lithiasic fragments.

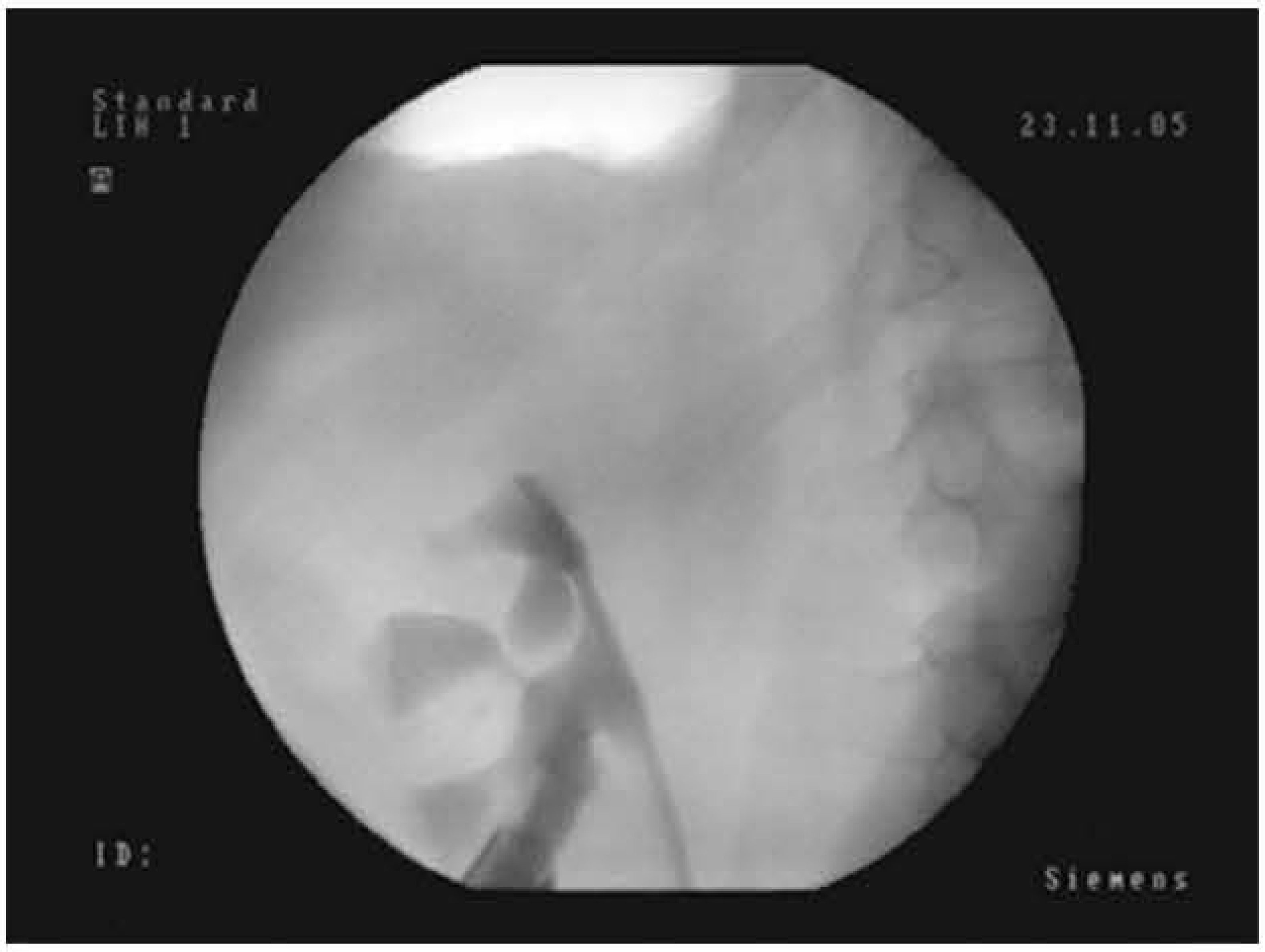
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FIGURE 3.79 Retrograde injection of contrast medium confirms the absence of lithiasic fragments.

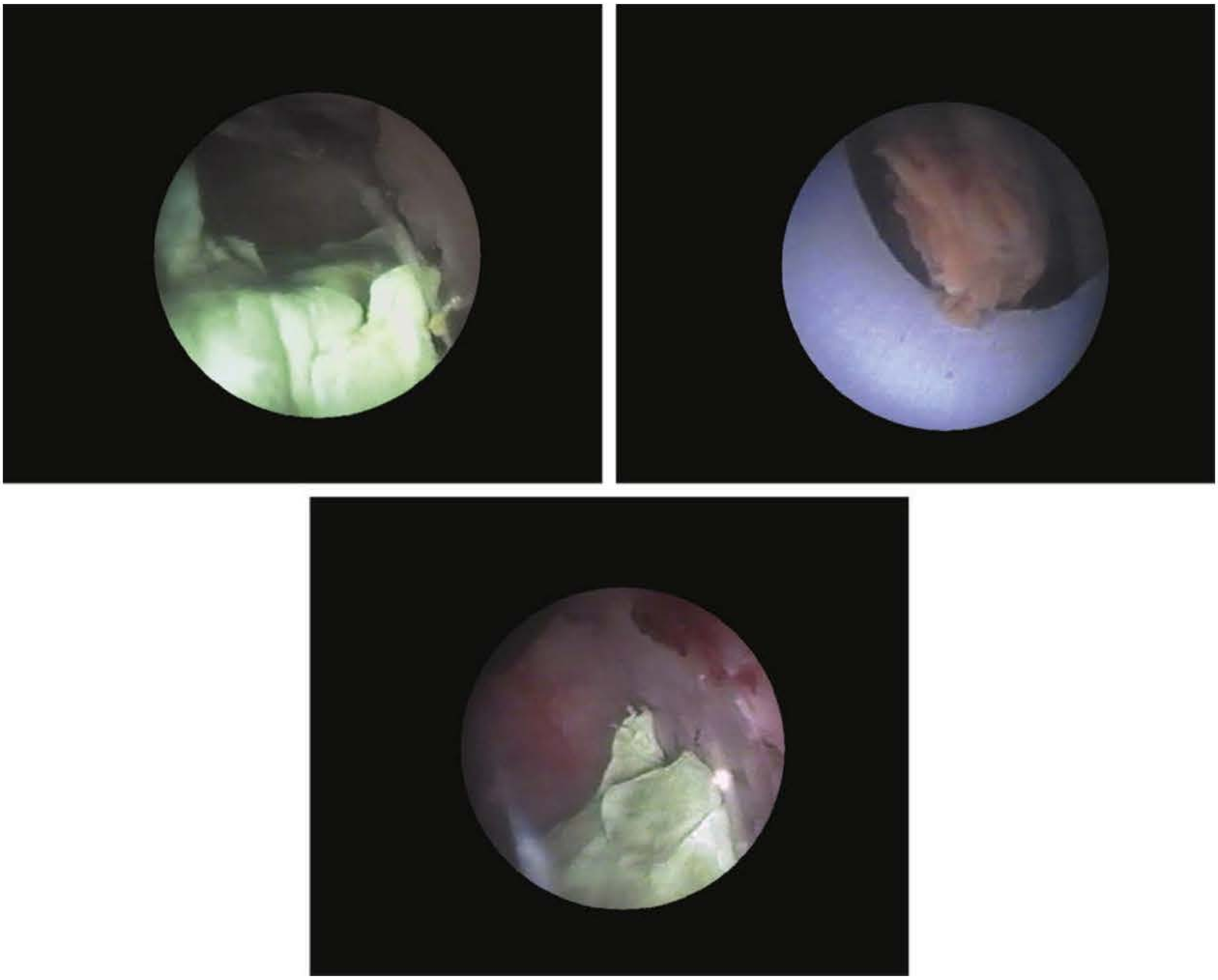

FIGURE 3.80 Aspects of soft pyelocaliceal lithiasis.

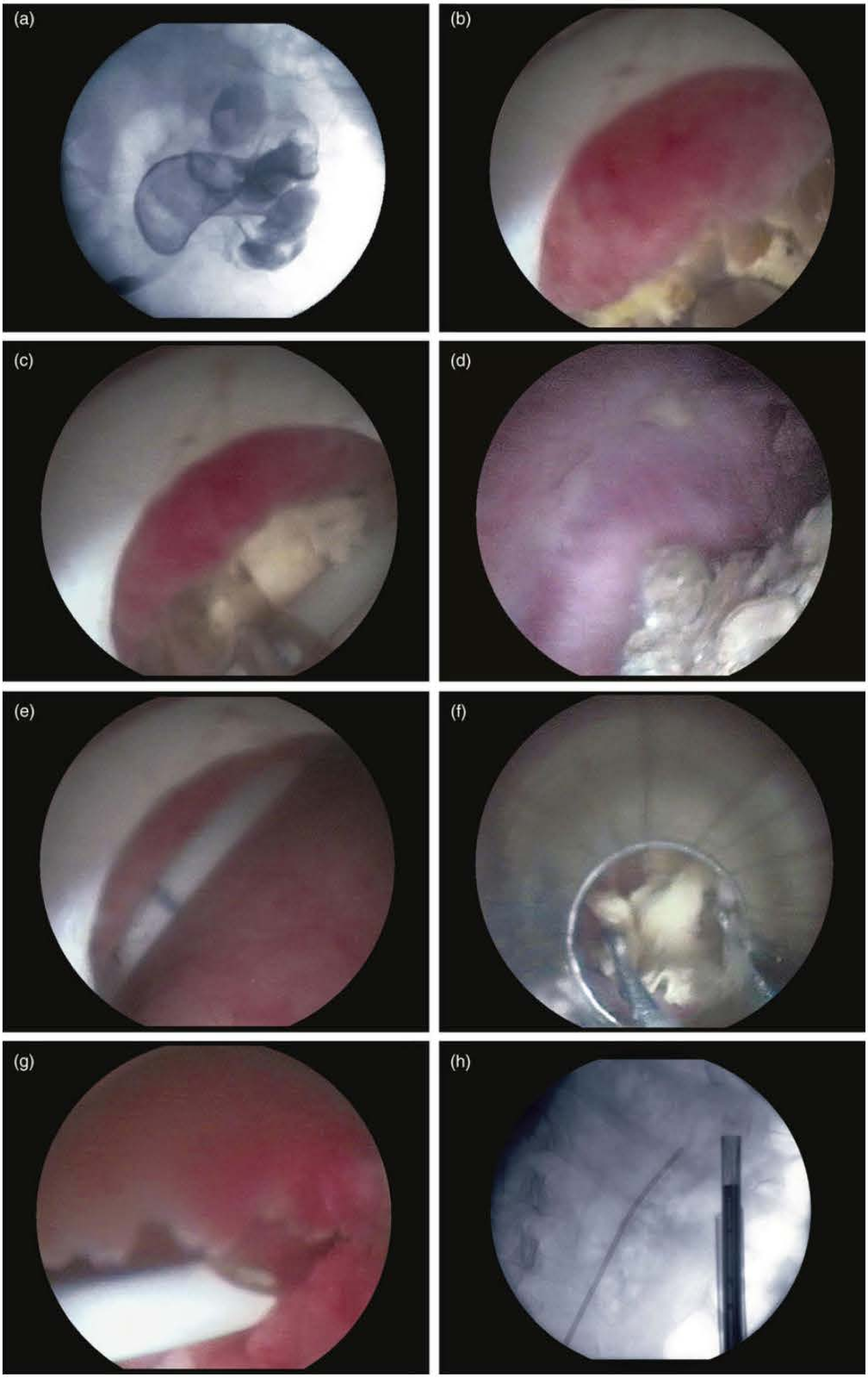

FIGURE 3.81 Soft staghorn lithiasis (a), extraction of the lower caliceal and pyelic pieces (b–d) until these areas are completely free (e), followed by the approach of the middle and upper calyces (f–h).

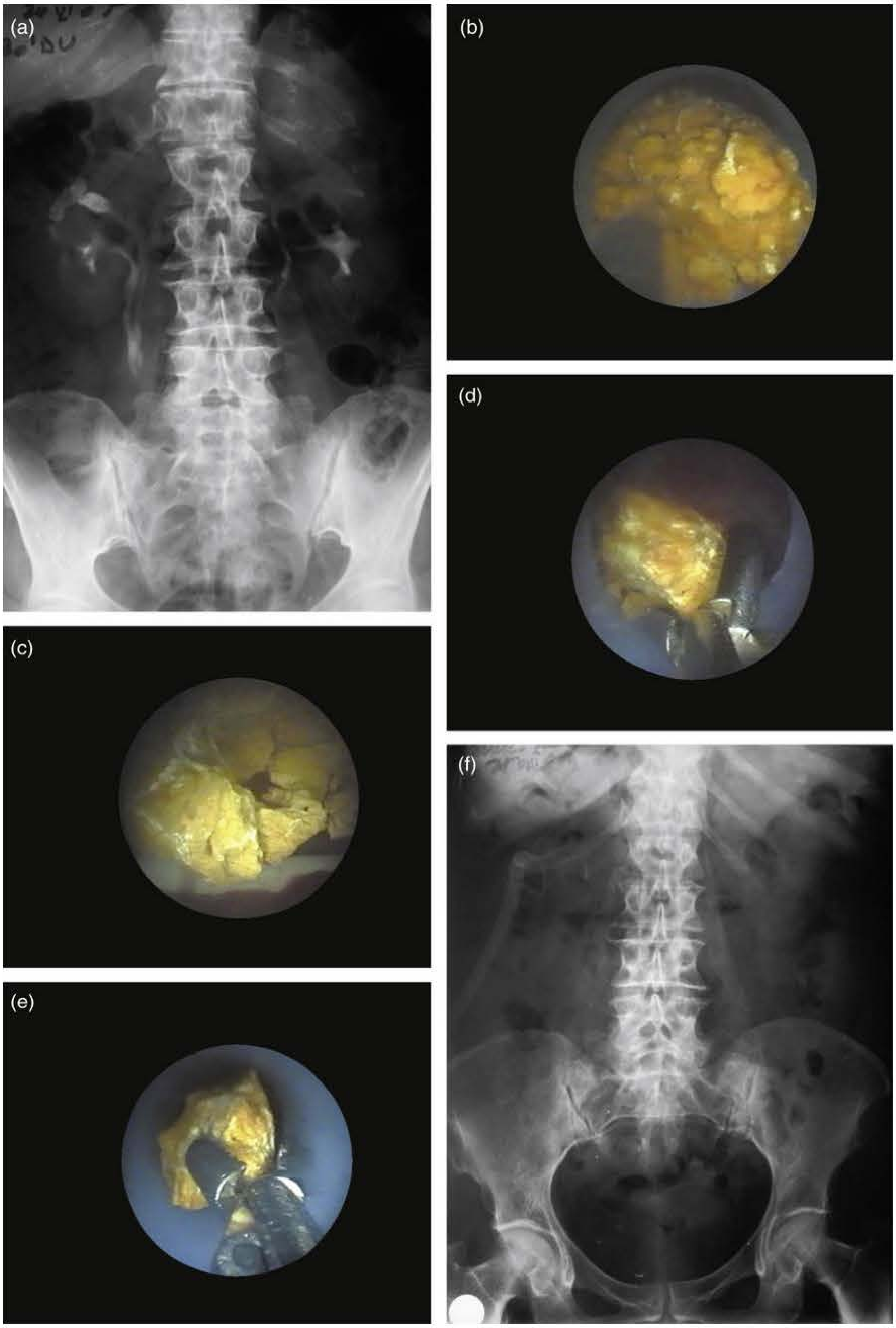

FIGURE 3.82 **Pyelic stone in the upper pyelon (a), fragmented balistically (b, c) and extracted with the extracting forceps (d, e), with a stone-free aspect at the end of the intervention (f).**

3.12.2 Pyeloureteral Duplicity

Percutaneous interventions on incomplete pyeloureteral duplicity represent a particular situation regarding only the adequate opacification of the pyelon which is to be approached. If this is achieved, from that moment, the intervention is carried out identically to a procedure for lithiasis on a kidney without duplicity (Fig. 3.82).

3.12.3 Horseshoe Kidney

Flexible nephroscopy plays an important role during percutaneous interventions on a horseshoe kidney. The approach of this kidney raises a number of problems because of the organ's modified relations and the vascular anomalies that are frequently associated (Matlaga et al., 2005).

Although the puncture of the upper calyx presents a low associated morbidity in these patients, this type of approach for stones located in caliceal cavities with an abnormal position (especially for inferior ones with a medial orientation) may be difficult, if not impossible, in the absence of the flexible nephroscope.

Also, due to the association of rotation anomalies of the kidney, the renal pelvis is situated anteriorly, and the length of the nephrostomy tract may exceed that of the rigid nephroscope, requiring the use of the flexible one (Fig. 3.83) (Lingeman et al., 2007).

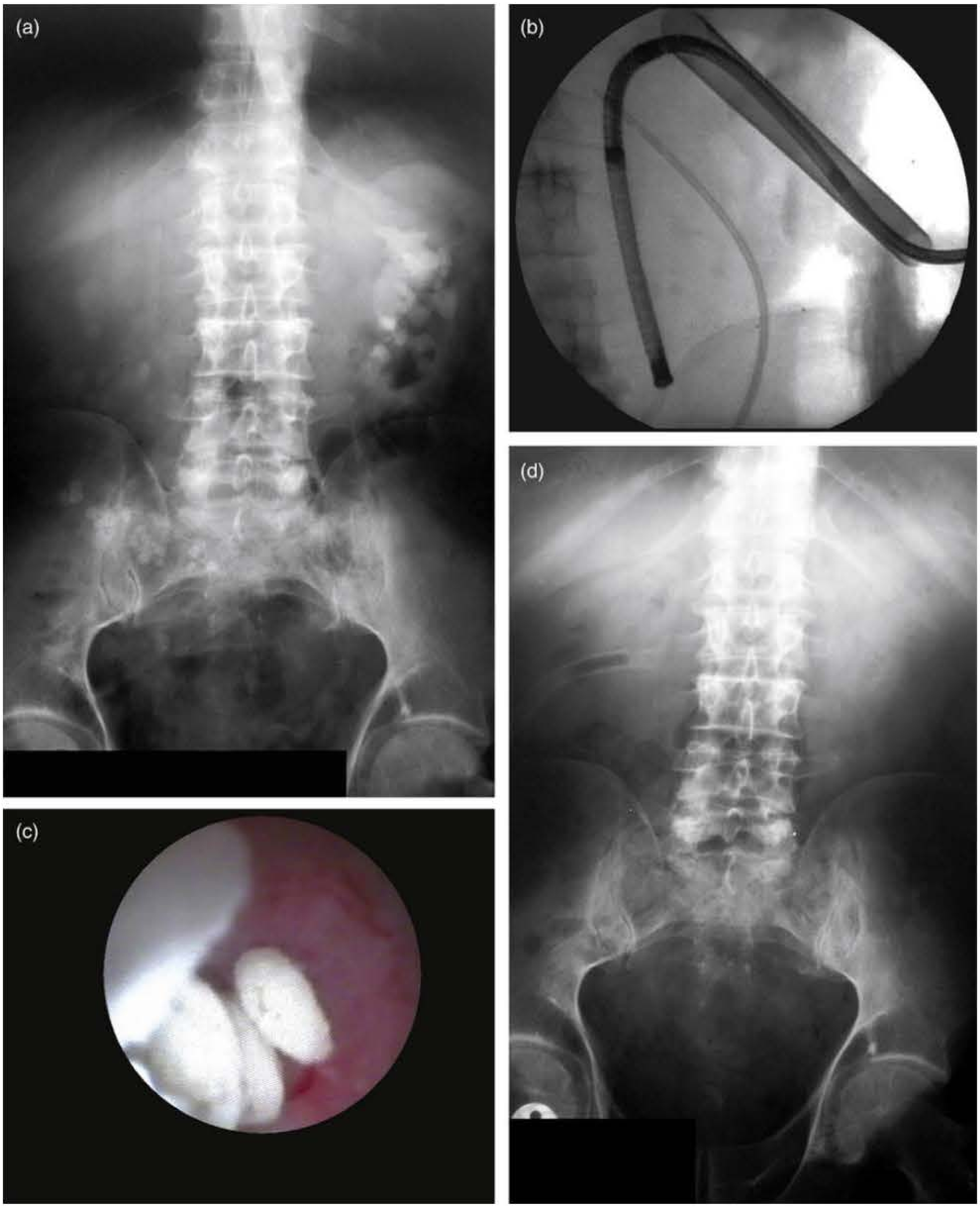

FIGURE 3.83 **Multiple lithiasis in the right lower cavities of a horseshoe kidney (a), approached through the upper calyx with the flexible nephroscope (b, c), and a stone-free aspect at the end of the intervention (d).**

Thus, in a group of 37 patients with lithiasis on horseshoe kidneys treated by percutaneous nephrolithotomy, Raj and coworkers reported a stone-free rate of 87.5%, the use of the flexible nephroscope being necessary in 84% of cases. In most cases, due to the particular position of the kidney, with the lower pole frequently anteriorized and much lowered, the puncture tract was performed at the upper caliceal level (63% of patients) (Raj et al., 2003).

In a similar study, Al-Otaibi obtained a stone-free rate of 75% after a single intervention and using a single percutaneous tract, respectively, of 91.7% after second-look interventions. In this study, the use of the flexible nephroscope was essential in 9 of the 11 patients in whom the complete removal of stones was obtained (Al-Otaibi and Hosking, 1999).

3.13 COMPLICATIONS OF PERCUTANEOUS APPROACH IN RENAL LITHIASIS

Even if percutaneous approach in renal lithiasis is generally a safe therapeutic option, less invasive than open surgery, it can be associated with specific complications. Many of these occur as a result of the initial maneuvers for performing the puncture, with injuries of the neighboring organs, while others occur intraoperatively, during other steps, or postoperatively.

Data in the literature reports an overall rate of complications varying between 29.2% and 83% (Michel et al., 2007; Tefekli et al., 2008).

The perioperative complications of percutaneous approach in renal lithiasis can be classified using the modified Clavien system. This system classifies the surgical complications into five grades (Table 3.1) (Tefekli et al., 2008).

In a study conducted by Tefekli and coworkers on 811 patients with PCNL, the general rate of perioperative complications was 29.2%, of which 4% were grade 1, 16.3% were grade 2, 6.6% were grade 3a, 2.8% were grade 3b, 1.1% were grade 4a, 0.3% were grade 4b, and there was one death (0.1%). The most common grade 1 complication was fever (3%), while from grade 2 complications, 11% of patients required blood transfusions and 4% presented urinary fistula for less than 12 h. The placement of a Cook catheter for urinary fistula persisting over 24 h was necessary in 4% of cases, representing the most frequent grade 3a complication. From grade 4a complications, nephrectomy was necessary in four cases (0.4%).

Also, in a series of 5803 patients with PCNL, the distribution of the modified Clavien system scores was: no complications (79.5%), grade 1 (11.1%), 2 (5.3%), 3a (2.3%), 3b (1.3%), 4a (0.3%), 4b (0.2%), and 5 (0.03%) (Table 3.2) (de la Rosette et al., 2011).

3.13.1 Intraoperative Incidents and Complications

3.13.1.1 Deterioration of Instruments

Deterioration of the endoscopes or accessory instruments can occur during any percutaneous intervention and can require interrupting the procedure. The small residual fragments in the pyelocaliceal system or even extrarenal may require additional maneuvers for finding and extracting them (Fig. 3.84).

TABLE 3.1 Classification of Surgical Complications According to the Modified Clavien System

Grade 1: Any deviation from the normal postoperative evolution without requiring pharmacological, surgical, or endoscopic treatment or by interventional radiology. The therapeutic regimens allowed include medications such as antiemetics, antipyretics, analgesics, diuretics, electrolytes, or physiotherapy. This grade also includes infections of the open wounds.

Grade 2: Complications that require pharmacological treatment with medications other than those allowed for grade 1 complications. Blood transfusions and parenteral nutrition are also included.

Grade 3: Complications that require surgical or endoscopic treatment or interventional radiology.
Grade 3a: Intervention that is not performed under general anesthesia.
Grade 3b: Intervention under general anesthesia.

Grade 4: Life-threatening complications (complications related to the nervous system are included) that require treatment in an intensive care unit.
Grade 4a: Dysfunction of a single organ (including dialysis).
Grade 4b: Multiorgan dysfunction.

Grade 5: Death of the patient.

TABLE 3.2 Distribution of PCNL Complications in the CROES Study

No complications	79.5%
Grade 1	11.1%
Grade 2	5.3%
Grade 3	*IIIa*: 2.3% *IIIb*: 1.3%
Grade 4	*IVa*: 0.3% *IVb*: 0.2%
Grade 5	0.03%

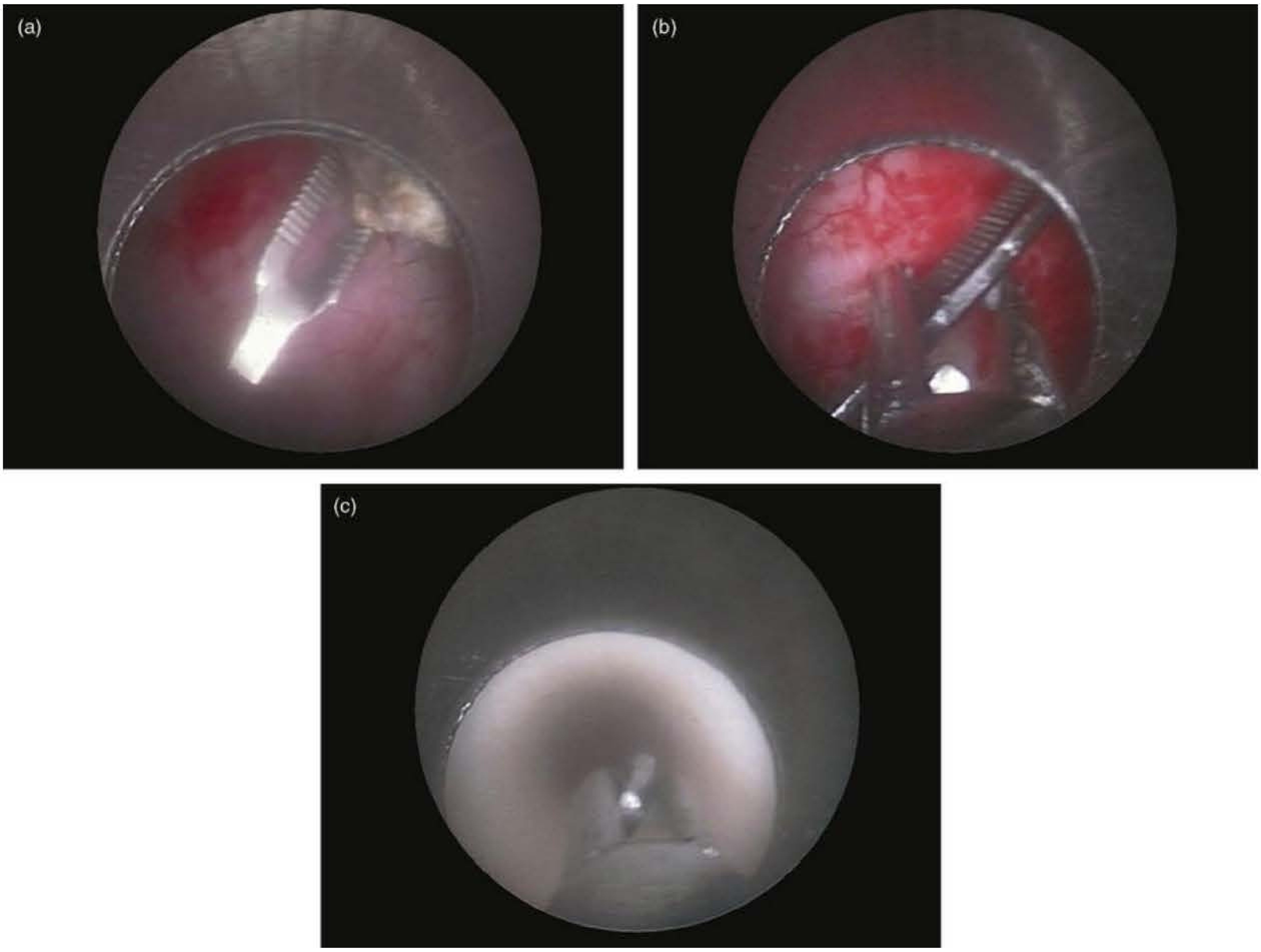

FIGURE 3.84 **Grasper fragment in the renal pelvis (a), extracted with the forceps (b, c).**

3.13.1.2 Losing the PCNL Tract During the Procedure

This intraoperative incident may occur due to ample respiratory movements in a patient with a mobile kidney, during maneuvers for the tract's dilation when the guidewire can leave the pyelocaliceal system, or during the maneuvers for extracting the lithiasic fragments in the conditions of a narrow caliceal infundibulum (Boja et al., 2008). The favoring factors are represented by the presence of stones that mold the caliceal cup and do not allow the correct placement of the guidewire, as well as by a faulty technique when, while performing the dilation, the different instruments are not slid on the guidewire along the axis, determining its bending and its accidental extraction.

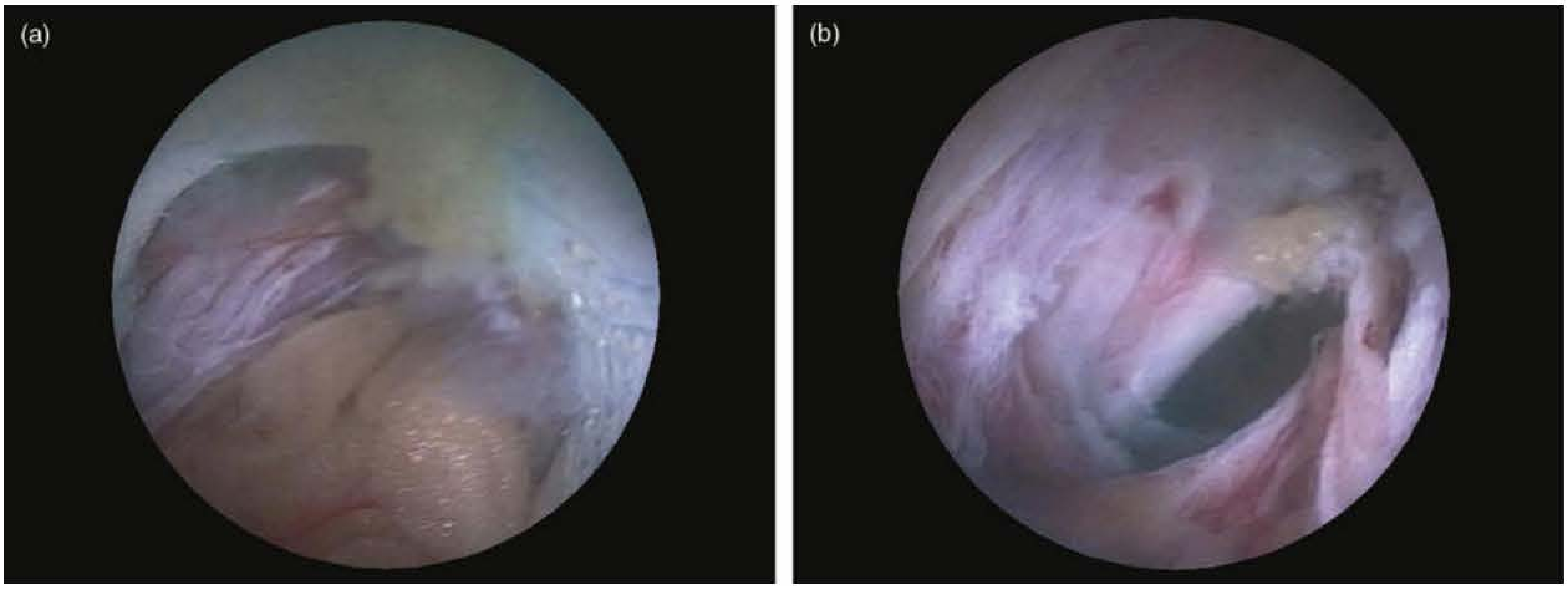

FIGURE 3.85 **Loss of the percutaneous tract (a) and finding it again under visual control (b).**

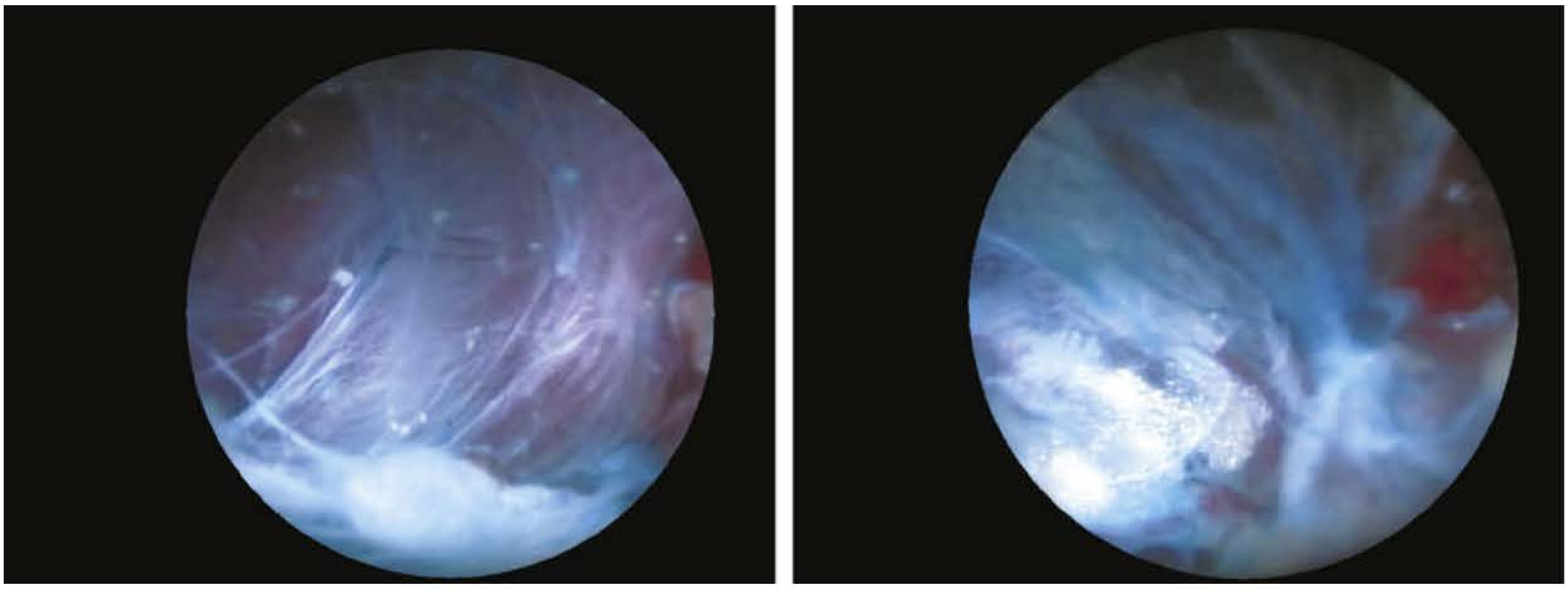

FIGURE 3.86 **Finding the percutaneous tract again, guided by injection of methylene blue through the ureteral catheter.**

The rate of this intraoperative incident is approximately 1% (Miclea et al., 2006).

The use of an adequate guidewire is one of the methods for preventing this complication. If the tract is lost, it may be found again by visual, endoscopic control (Fig. 3.85), eventually aided by injecting methylene blue (Fig. 3.86) or air through the ureteral catheter, or a new puncture may be necessary, especially when the incident occurred during dilation (Mulțescu et al., 2011).

3.13.1.3 Perforation of the Renal Pelvis

Perforation of the renal pelvis is one of the major intraoperative complications that is usually diagnosed intraoperatively (Fig. 3.87). Its incidence is approximately 3.4% (de la Rosette et al., 2011).

The most frequent causes are represented by the aggressive insertion of the serial dilators or by maneuvers performed during intracorporeal lithotripsy. Recent infection and inflammation that determine friability of the renal pelvis wall are factors that favor perforation (Gupta et al., 2007). During lithotripsy, the renal pelvis wall is injured most frequently when the procedure is executed in contact with the medial wall. Brutal maneuvers, increased manual pressure during lithotripsy with rigid probes (pneumatic or ultrasonic) or the insertion of extracting instruments without visual control increase the risk of this complication.

Detection of the renal pelvis lesion usually requires interrupting the procedure. Placing the nephrostomy tube (eventually a ureteral stent also) is usually sufficient for a favorable evolution after this type of complication (Pardalidis and Smith, 1995). The urothelium usually closes within 24–48 h in case of an adequate drainage, sealing

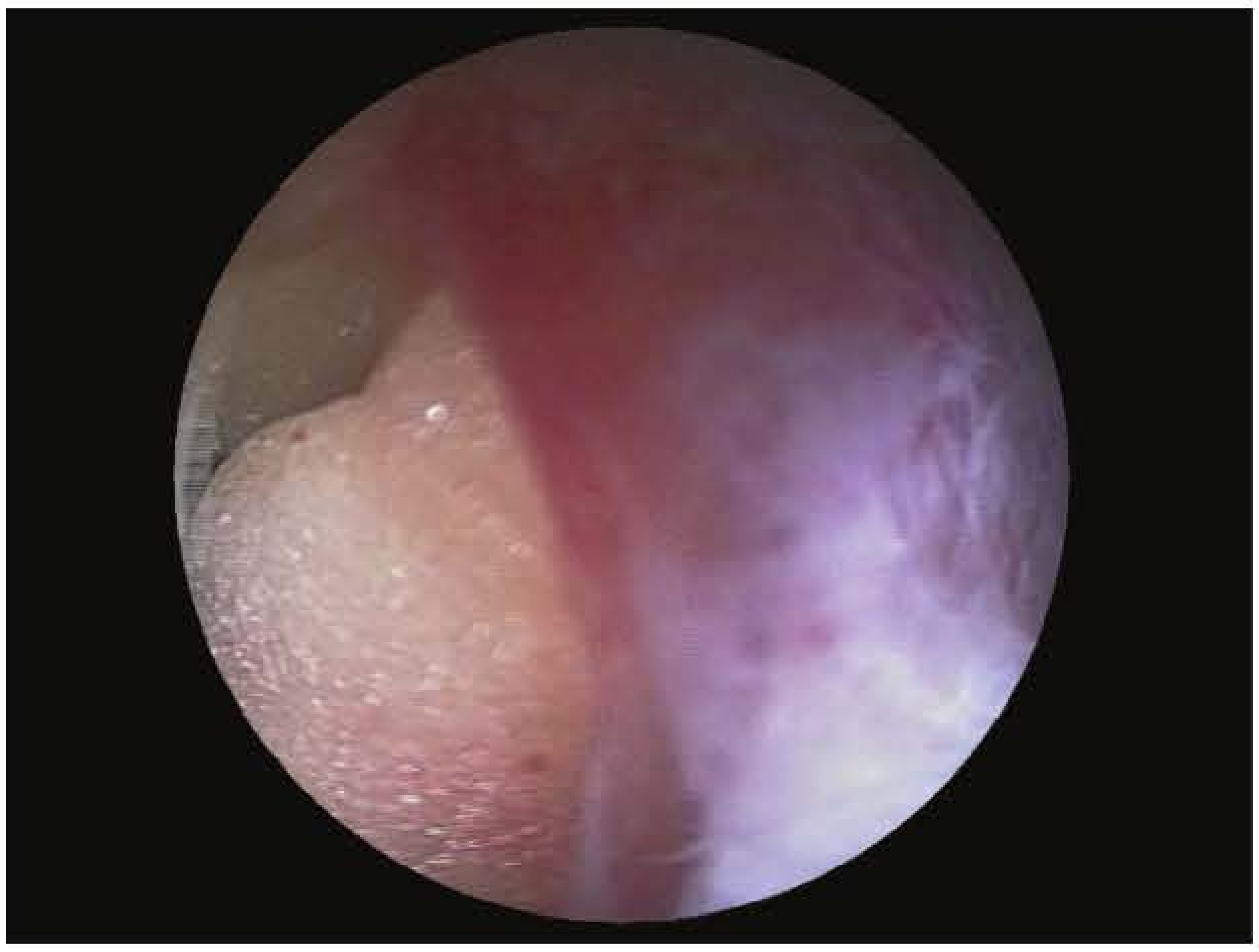

FIGURE 3.87 Perforation of the renal pelvis wall during lithotripsy.

the lesion. An antegrade pyelography can be performed before another percutaneous procedure or for suppressing the nephrostomy tube, which must confirm the absence of contrast medium leakage.

3.13.1.4 *Migration of an Extrarenal Lithiasic Fragment*

A complication secondary to the previous one is the migration of an extrarenal lithiasic fragment. This undesired incident is usually without clinical significance if the urine and the stone are not infected and the lithiasic material does not remain at the submucosal level (Verstandig et al., 1986). An attempt to extract the migrated fragment must be avoided because it may determine an increase of the perforated area (Evans and Stoller, 1993).

3.13.1.5 *Pyeloureteral Junction Wounds*

Pyeloureteral junction wounds may occur secondary to the extraction of a pyelic stone impacted at the junction level, especially in the case of tractioning with an excessive force. The consequence of this complication is usually the development of a ureteropelvic junction stenosis. A ureteral stent can be placed in order to try to prevent this evolution.

3.13.1.6 *Injuries of the Neighboring Organs*

The retroperitoneal localization of the kidney, in direct relation with the diaphragm, pleura, liver, spleen, duodenum, and colon, may create the possibility of injuring these structures and organs during percutaneous procedures.

The early detection of these types of complications is extremely important for the outcome of the operated patient. Most complications can be treated endourologically or conservatively, but some cases require open surgical interventions.

Pleural and pulmonary lesions may occur during the maneuvers of puncturing and dilating the percutaneous tract. Intraoperatively, pleural lesions are suspected when ventilatory difficulties and/or alterations of the respiratory parameters occur, or when intrapleural contrast medium is detected. Injury of the intercostal vessels during a supracostal approach may lead to hemothorax, which is frequently voluminous.

The risk of injuring the pleura and the lung increases if the puncture is performed above the XII-th rib. Thus, Munver et al. (2001), evaluating the morbidity associated with creating 300 access tracts during percutaneous interventions (98 supracostal and 202 subcostal), underline the fact that 7 of the 8 patients who developed intrathoracic complications presented supracostal access tracts. The methods for reducing the risk are represented by performing the puncture under ultrasonographic control or after exhaling.

The routine achievement of the percutaneous access through the lower calyx, combined with the use of flexible nephroscopy or ESWL for fragments that are inaccessible through this approach, practically avoid this complication.

These complications can be detected postoperatively by a simple chest radiography, some authors recommending to routinely perform this investigation in all cases in which intercostal punctures are made (Gupta et al., 2007). If the puncture is performed transpleurally, leakage of the irrigation fluid or entrance of air into the pleural space must be prevented. Patients who present small volume pneumothorax or hydrothorax may be only observed and monitored if respiratory problems do not occur (Shah and Assimos, 2006). The urgent placement of a thoracostomy tube may be required in the case of development of a significant hydrothorax or hemothorax or in the case of an unstable patient (Michel et al., 2007).

Very rarely, a nephropleural fistula may develop, being suspected when the intrathoracic fluid persists after placing the thoracostomy tube, requiring the placement of a ureteral stent (Shah and Assimos, 2006).

The duodenum is located antero-medially from the right kidney and may be injured during percutaneous maneuvers performed on the right side (Gupta et al., 2007). This is a rare complication and the treatment is usually conservative, consisting of drainage. The retroperitoneal segments of the duodenum can be involved (the second and third segments) and are diagnosed when the contrast medium that opacifies the pyelocaliceal system also determines opacification of the duodenum.

The colon is the most frequently injured abdominal organ during maneuvers that are carried out during percutaneous nephrolithotomy. The damage to the colon can occur when the puncture is performed lateral to the posterior axillary line or in rare situations in which the colon is situated retrorenally. Also, the displacement of the colon posterior to the kidney, with an increased risk of perforation, can be encountered in elderly patients with chronic constipation or in patients with secondary greatly distended descending colon (e.g., after abdominal surgery).

In a retrospective study conducted on 5039 PCNL procedures, colon perforation was described in 0.3% of cases, being more frequently encountered on the left side. A colo-cutaneous fistula developed in 33.3% of these cases (el-Nahas et al., 2006b).

The perforation of the colon must be suspected during the intervention, when feces or gas are exteriorized through the puncture needle. Immediately after the procedure, the signs of this complication are represented by diarrhea or hematochezia, signs of peritoneal irritation or even exteriorization of gases or feces through the nephrostomy tube. Injection of contrast medium through the nephrostomy tract can opacify the colonic lumen.

Extraperitoneal perforation is usually resolved through conservative treatment, the placement of a ureteral stent being necessary; however, there are also cases that may require colostomy. The nephrostomy tube can sometimes be repositioned inside the colonic lumen, transforming it into a colostomy tube.

Signs of peritoneal irritation appear if the colon is damaged intraperitoneally, requiring emergency surgical treatment.

Lesions of the spleen or liver are rare and occur more frequently in the case of splenomegaly or hepatomegaly. In the absence of pathological enlargement of these organs, in case of subcostal punctures of the lower pole, the risk of injuring these organs is extremely low. The risk can be higher if the upper renal pole is punctured, especially if the puncture is done during inhaling or above the XI-th rib.

If the spleen's injury leads to its perforation or laceration, a significant bleeding occurs that usually requires emergency surgical exploration and splenectomy (Gupta et al., 2007). The hepatic lesions usually benefit from conservative treatment, surgical exploration rarely being necessary (Gupta et al., 2007). The lesions of the gallbladder usually determine coleperitoneum and subsequently coleperitonitis, also requiring surgical exploration and colecystectomy.

3.13.1.7 Bleeding

Bleeding is one of the most frequent and disturbing complications encountered during percutaneous procedures. It may occur during the procedure, in the immediate or late postoperative period, or after several days or even weeks, these last two situations being addressed separately.

The source of the bleeding can be represented by the traumatized renal parenchyma, the branches of the renal artery or vein adjacent to the pyelocaliceal system, or the perinephritic vessels. Excessive intraoperative bleeding may occur most frequently during the puncture or tract dilation maneuvers.

Most intraoperative bleedings have venous origins and are detected when, after irrigation is stopped, an important volume of blood is exteriorized through the nephrostomy tract. Sometimes the injection of the contrast medium into the pyelocaliceal system may determine opacification of the venous vascular system (Shah and Assimos, 2006). In case of bleeding from an arterial source, the exteriorized blood has a bright red aspect and presents a pulsatile flow.

Punctures in an excessively medial position, multiple punctures, as well as those at the level of the kidneys with anatomic anomalies are associated with a higher risk of bleeding (Gupta et al., 2007). A common source of bleeding during the PCNL procedure is the nephrostomy tract itself. These bleedings can be prevented if the kidney is punctured strictly through the caliceal cup and if a minimal angulation of the dilation instruments and of the nephroscope's axis is maintained. In order to avoid an exaggerated angulation, the flexible nephroscope can be used for the approach of lithiasic fragments located in areas that are more difficult to access (Michel et al., 2007). Also, access to a posterior calyx is recommended, this pathway being usually situated along the intersegmental avascular plane (Mahaffey et al., 1994).

The procedure should be interrupted if bleeding significantly hinders visibility. After placing the nephrostomy tube, this must be clamped for a period of 40–60 min with the purpose of achieving a tamponade at the level of the collecting system with formation of clots at this level. An important bleeding can require tamponade with a balloon nephrostomy tube (Kaye catheter) that can be maintained up to 2–4 days, depending on the necessities (Gupta et al., 2007).

Bleeding from a venous source can usually be controlled through these methods (Srivastava et al., 2005). A second procedure can be performed only if urine has become clear, usually after 24–48 h.

If bleeding is important and/or persistent, a renal angiography can be performed, with the possibility of a supraselective embolization (Michel et al., 2007). These bleedings are usually arterial, occurring, however, with a low frequency (Gupta et al., 2007). Open surgical intervention is necessary in these situations if the other methods fail or in the absence of an angiography unit, and consists of hemostasis, partial nephrectomy, or, very frequently, nephrectomy (Gupta et al., 2007).

3.13.1.8 Absorption of the Irrigation Fluid

The absorption of the irrigation fluid is due to high pressure irrigation in the case of a venous injury or perforation of the pyelocaliceal system. This can determine a picture similar to that from the post-TUR syndrome, and the use of an isotonic solution is recommended for irrigation, in order to minimize the risks of such an event, thus avoiding the risk of dilutional hyponatremia (Gupta et al., 2007).

A thorough intraoperative monitoring of the patient helps to detect this complication, especially when a difference between the amount of fluid that enters and the amount that is evacuated is observed, or when hypertension or hypoxemia occur during the intervention (Shah and Assimos, 2006).

3.13.1.9 Leakage of the Irrigation Fluid

This complication is most frequently due to perforation of the pyelocaliceal system or of the ureter. Perforation is suspected when the perirenal fat or other anatomic structures surrounding the kidney are visualized (Lee et al., 1987a).

3.13.1.10 Hypothermia

Hypothermia can occur secondary to vasodilation induced by spinal anesthesia, during very long procedures, favored also by the exposure of large corporeal areas to a low temperature or to irrigation with cold fluid (Roberts et al., 1994). The use of heated irrigation fluid limits this undesired event.

3.13.1.11 Allergic Reactions to Contrast Medium

These types of allergic reactions may occur, but are generally rare. If a significant history of allergy exists, steroids can be administered preoperatively (prednisone, hydrocortisone), while antihistamines, steroids, or epinephrine are administered if the problem appears during the intervention and may even require interrupting the procedure.

3.13.2 Early Postoperative Complications

The early postoperative complications can be divided into:

- minor (that can be resolved by conservative treatment) – transient fever, clinically insignificant bleeding, urinary infection without signs of urosepsis, renal colic
- major (that may require surgical or endoscopic treatment, life-threatening) – septicemia, renal bleeding that requires angiographic intervention, retroperitoneal hematoma, acute pancreatitis

3.13.2.1 Postoperative Bleeding

Postoperative bleeding may occur after inserting the nephrostomy tube and is more frequently due to an important venous lesion. Postoperative bleeding can also occur as a result of migration of the nephrostomy tube outside the kidney or secondary to its withdrawal.

When the bleeding occurs secondary to withdrawal of the drainage, it is usually from a venous cause and can be controlled by compressive dressings or sometimes by reinserting the nephrostomy tube and maintaining it for several days, until the urine becomes clear. Staghorn calculi, multiple tracts, diabetes mellitus, and large calculi seem to be associated wih a higher risk of postoperative bleeding (Turna et al., 2007).

Most bleedings are minor, clinically insignificant, but in some cases the blood loss is severe and requires blood transfusions. In a series of 5803 patients with PCNL, de la Rosette et al. (2011) observed significant bleeding in 7.8% of cases, hematological re-equilibration being necessary in 5.7% of patients.

Severe late postoperative bleeding may occur in the first 3–4 weeks after the intervention, in most cases due to the injury of the segmental arteries. These may lead to late bleeding through the development of pseudoaneurysms or arterio-venous fistulas and usually require therapeutic intervention (embolization). In a series of 1854 patients with percutaneous nephrolithotomy, 1.4% of them presented complex hemorrhagic complications that required angiography and/or embolization for controlling the bleeding (Srivastava et al., 2005).

3.13.2.2 *Retroperitoneal Hematoma*

This is a complication that may occur consecutive to bleeding and consists of the sanguinolent infiltration of the perirenal fat or the formation of a circumscribed hematic collection in the retroperitoneum (Boja et al., 2008). Small hematomas can resorb spontaneously under conservative treatment, requiring only monitorization. Voluminous hematomas usually require open surgical intervention for hemostasis, and sometimes nephrectomy is necessary.

Fever is a usually minor complication, but occurs in a significant percentage of cases, between 2.8% and 32.1% according to the literature (Michel et al., 2007; Tefekli et al., 2008; de la Rosette et al., 2011).

An operatory time of over 120 min, a volume of irrigation fluid used over 20 L, and postoperative blood transfusions are factors associated with the occurrence of fever (Vorrakitpokatorn et al., 2006).

Most cases are resolved by antibiotic and antipyretic treatment, but in some cases fever can be the first sign of more severe complications.

3.13.2.3 *Septic Complications*

Sepsis can be correlated with *de novo* infection, associated with the percutaneous access itself or with a pre-existing infection, secondary to lithiasis. The risk of sepsis secondary to bacteremia due to pyelovenous or pyelolymphatic bacterial reflux is significant in the absence of an adequate antibiotic treatment (Rao et al., 1991).

The urine must be sterile in order to perform an elective PCNL intervention, any infection requiring preoperative antibiotic treatment according to the antibiogram. However, this is not possible every time, especially in patients with a pre-existing nephrostomy tube, in those with struvite lithiasis, or in those with a urethrovesical catheter.

Ureteral obstruction secondary to migration of the lithiasic fragments is another possible postoperative complication. In a series of 88 cases of PCNL, Neto et al. (2007) reported a migration rate of 3.4%, patients who required ureteroscopy with lithotripsy and placement of a ureteral stent.

Leakage of urine secondary to PCNL procedure can occur in the case of severe perforation of the pyelocaliceal collecting system or of the nephrostomy tract. After the intervention, this complication is suggested by flank pain and signs of infection (Michel et al., 2007). If a urinoma appears, maneuvers for percutaneous drainage and for drainage of the pyelocaliceal system with a double J stent may be necessary. If the urinoma is large or is infected, open surgical exploration by lombotomy is required, with evacuation of the collection and lumbar drainage.

3.13.2.4 *Nephrocutaneous Fistula*

The nephrocutaneous fistula is a rare complication (White and Smith, 1984). Prolonged postoperative drainage may be caused by the obstruction of the urinary tract secondary to mucosal edema of the ureteropelvic junction, of the ureter or the ureteral orifice, to an obstructive stone, a blood clot or an infundibular, junction or ureteral stenosis. Resolving this problem requires, in most cases, placing a double J catheter and eventually resolving the obstructive cause in a secondary step (Shah and Assimos, 2006).

3.13.3 Late Postoperative Complications

Late complications occur in fewer than 2% of patients (Moskowitz et al., 1989).

3.13.3.1 *Pyeloureteral Junction Stenosis and Ureteral Stenosis*

Pyeloureteral junction stenosis may occur secondary to a pyelic stone impacted at the junction level for a long time or as a result of junction wounds during percutaneous intervention. It is necessary to place a ureteral stent in order to prevent this type of complication. Ureteral stenoses appear most frequently in the proximal segment (Lang, 1987).

3.13.3.2 *Infundibular Stenosis*

Stenosis of the caliceal infundibulum is a complication which usually becomes manifest during the first year after the percutaneous intervention and may require endourological treatment. It may occur after laborious interventions, voluminous stones that require multiple procedures, or in the case of prolonged postoperative drainage through the nephrostomy tube (Parsons et al., 2002).

3.13.3.3 *Arterio-Venous Fistula With or Without Pseudoaneurysm*

Severe bleeding which may occur 2–3 weeks after the intervention is usually secondary to an arterio-venous fistula, the elective treatment consisting of selective embolization (Boja et al., 2008).

3.13.3.4 *Perirenal Purulent Collections*

Late perirenal suppurations after PCNL are very rare complications (0.02%), usually due to the infection of an undetected urinoma (Boja et al., 2008).

3.13.3.5 *Residual Foreign Bodies*

Residual foreign bodies can be represented by parts of lithotripsy probes, different fragments of guidewires, stents, angiography catheters, or laser fibers (Shah and Assimos, 2006). Their persistence may determine infection, granulomatous reaction, or formation of new stones. They are usually removed through another percutaneous intervention with rigid or flexible instruments.

3.14 RESULTS OF PERCUTANEOUS APPROACH FOR RENAL LITHIASIS

Presenting the results of percutaneous approach in this pathology is not an easy mission. An analysis of the contemporary urological literature demonstrates a surprising variability in defining the success of percutaneous interventions and even of the term "stone-free" (Table 3.3). No less than seven different definitions can be encountered in 249 studies, the most frequent, found in 47% of cases, being the "absence of stones." It should be mentioned that only 68% of the papers mention the precise definition of the intervention's success. Moreover, heterogeneity can be observed regarding the imagistic methods used for defining the "stone-free" status: the most frequent method is simple reno-vesical radiography (28%), followed by the combination between ultrasonography and reno-vesical radiography (22%). All these underline the importance of homogenizing the modalities for reporting data regarding the treatment of urinary lithiasis, and implicitly of its percutaneous approach (Deters et al., 2011).

The influence of different parameters regarding results are added to this variability of reporting. Knowing these parameters and their impact on the success rate is essential for an adequate selection of cases.

Regarding the patient's position, percutaneous nephrolithotomy in supine position has been used for over a decade and seems to provide success rates similar to that performed in prone position. The supine position, with all its variants (complete, Valdivia, Galdakao-modified Valdivia, Barts-modified Valdivia, and modified flank-free Barts supine) reduces the operatory time, at the same time allowing the quick access of the anesthesiologist to the respiratory tract, as well as the possibility of a simultaneous intrarenal retrograde approach, but data regarding their benefits and disadvantages are limited (Kumar et al., 2012).

3.14.1 Results of Rigid Percutaneous Nephrolithotomy

The success rate (defined as the stone-free rate) and the factors that influence it were evaluated in a recent study conducted in a group of 351 patients with renal lithiasis who benefited from PCNL with a single tract. The overall success rate was 76%, while the factors that influenced it directly were the dimensions of the stone, its location in the upper calyx, and performing ESWL before PCNL (Shahrour et al., 2012).

Minimally invasive percutaneous nephrolithotomy (miniperc), initially developed as an efficient therapeutic method for small stones, can also be an efficient and safe procedure for voluminous stones (stones >20 mm or staghorn calculi). Abdelhafez et al. (2012) reported a success rate of 78.3% after a single procedure and 95.2% after using an auxiliary procedure (miniperc, ureterorenoscopy, or ESWL), with a low morbidity rate (26.5%), the stone-free rate being influenced especially by the complexity of the stones (96.9% in simple lithiasis vs. 66.7% in voluminous lithiasis, multiple staghorn lithiasis, etc.).

TABLE 3.3 The Efficiency of Percutaneous Interventions for Upper Urinary Tract Lithiasis

Author	No. of patients	"Stone-free" rate (%)	Observations
Shahrour et al. (2012)	351	76	
Tie-Jun et al. (2012)	150	83	
Knox et al. (2012)	47	69.7	
Armitage et al. (2012)	987	78	
Shin et al. (2011)	698	88.8	
Srivastava et al. (2011)	22	88	Chronic kidney failure
Altunrende et al. (2011)	430	74.5	
Honey et al. (2011)	164	94.1	
Honey et al. (2011)	154	89.8	Supracostal approach
Hoznek et al. (2011)	31	90	Solitary stones, Galdakao-Valdivia position
Hoznek et al. (2011)	9	78	Multiple lithiasis, Galdakao-Valdivia position
Hoznek et al. (2011)	7	43	Staghorn lithiasis, Galdakao-Valdivia position
Mousavi-Bahar et al. (2011)	597	89.4	
Wiesenthal et al. (2011)	43	95.3	
Alobaidy et al. (2011)	602	71.4	
de la Rosette et al. (2011)	5803	75.7	
Conort et al. (2010)	60	75	Simultaneous bilateral approach
Akman et al. (2010)	1658	86.2	
Falahatkar et al. (2010)	14	78.6	Supine position, ultrasonographic control
Falahatkar et al. (2010)	14	71.4	Supine position, fluoroscopic control
Goumas-Kartalas and Montanari (2010)	9	66.6	Spinal anomalies
Caione et al. (2010)	33	74	
Akman et al. (2010)	244	70.1	Staghorn lithiasis, a single tract
Akman et al. (2010)	169	81.1	Staghorn lithiasis, multiple tracts
Pardalidis et al. (2010)	144	96.7	Lower caliceal lithiasis, after a SWL session
Zhu et al. (2010)	44	81.8	Pneumatic lithotripsy
Zhu et al. (2010)	54	92.9	Swiss Lithoclast Master
Zhu et al. (2010)	56	88.9	Low-power Ho:YAG lithotripsy
Zhu et al. (2010)	38	78.9	High-power Ho:YAG lithotripsy
Kuzgunbay et al. (2010)	300	75	Chronic kidney failure
Soucy et al. (2009)	1338	78	

The age of the patients is a factor that can influence the rate of complications and the duration of hospitalization after PCNL rather than the success rate (Okeke et al., 2012).

Placing a percutaneous nephrostomy tube represents a part of the standard PCNL procedure. The procedure has been modified in recent years by replacing the nephrostomy tube with internal drainage through a JJ ureteral stent: tubeless PCNL. Although still controversial, this type of procedure is characterized by many authors as being safe and efficient. The procedure can also be efficient in children, in obese patients, or in those with recurrent lithiasis after open surgery. Tubeless PCNL has the best results in selected cases: stones smaller than 3 cm, a single access tract, without residual stones, without iatrogenic lesions, minimal bleeding, the absence of the need for a second procedure (Agrawal and Agrawal, 2010).

An analysis of 24 studies (11 randomized and 13 nonrandomized, retrospective or prospective) showed that tubeless PCNL represents a viable alternative to the classic variant for uncomplicated cases, and there are no data to suggest that the absence of nephrostomy would compromise the patient's safety in any way. The tubeless method has also been successfully used in complex cases such as staghorn stones, ectopic or horseshoe kidney. The analysis did not remark significant differences between standard and tubeless PCNL regarding the stone-free rates. However, prospective randomized trials are necessary for the supine position in patients with multiple, complex, or staghorn stones (Amer et al., 2012). The absence of the nephrostomy tube after PCNL is the most important predictive factor for reducing the duration of hospitalization after PCNL (Akman et al., 2011). However, despite the favorable results reported in some trials, the method is contested by other authors, being considered by these authors as a useless risk.

The CROES study (Clinical Research Office of the Endourological Society Percutaneous Nephrolithotomy Global Study), conducted worldwide on a large group of patients, concluded that the stone's localization is an important predictive factor for the success rate. The caliceal localization of the stone is correlated with a higher rate of postoperative complications compared to pyelic localization; also, an increase of the stone's dimensions leads to a reduction of the stone-free rate, as well as an increase of the rate of complications (especially fever and the need for blood transfusions) (Xue et al., 2012).

Armitage and coworkers published a retrospective analysis of the results of percutaneous nephrolithotomy performed in different centers in Great Britain in the last 2 years (1028 procedures performed in 987 patients); 30% of them were performed for staghorn calculi, 30% for stones over 2 cm, 33% for stones between 1 cm and 2 cm, and 9% for calculi smaller than 1 cm. No statistically significant differences were observed between the rates of blood transfusions necessary according to the tract dilation modality (with balloon or sequential dilation) or between the rates of complications or of successful access, if performed by urologists or by radiologists. The stone-free rate was 78% (Armitage et al., 2012).

Gupta and coworkers published a study regarding the feasibility of PCNL in patients with a history of open surgical interventions, a new endoscopic intervention in this group of patients being difficult, due to the modification of the retroperitoneal anatomy. The conclusions of this study were that the approach of the pyelocaliceal system is statistically significantly more difficult in this category of patients; also, the tract's dilation is much more difficult due to retroperitoneal fibrosis. No statistically significant differences were observed regarding the operatory time (Gupta et al., 2011).

Shin and coworkers recently presented a retrospective analysis of a 16-year experience regarding the success rate after PCNL. Thus, the overall stone-free rate was 88.8%, while the initial rate, after a single procedure, was 69.9% (Shin et al., 2011).

A study conducted by Honey et al. (2011) compared the influence of the percutaneous tract's position in relation with the XII-th rib in prone percutaneous interventions, and concluded that the success rates do not present statistically significant differences: 89.8% in the supracostal approach versus 94.1% for the infracostal one.

The supracostal approach is the preferred solution in the case of staghorn calculi, upper lumbar ureteral calculi, and complex lower caliceal stones, being an adequate choice for direct access to the renal collecting system and the proximal ureter. Mousavi-Bahar and coworkers published a retrospective study regarding the safety and efficiency of PCNL with supracostal approach for the treatment of renal lithiasis. Supracostal approach was used in 123 cases (94% with puncture in the 11–12 intercostal space and the rest in the 10–11 intercostal space) under fluoroscopic guidance in prone position. The overall success rate was 89.4%. The success rate was 100% for stones smaller than 2 cm with ureteral or pyelic location and 77.4% for staghorn stones (Mousavi-Bahar et al., 2011).

The length of the percutaneous tract seems to also influence the intervention's success, at least in selected cases. Thus, in cases with solitary lithiasis of the upper pole, Aghamir et al. (2012) reported for cases in which the length of the percutaneous access tract was under 8 cm a success rate of 100% for the approach, which decreases to 83% if the length is between 8 cm and 12 cm and to 50% if the tract is longer than 12 cm.

Conort and coworkers published a retrospective analysis regarding the efficiency and morbidity of simultaneous bilateral PCNL in a group of 60 patients. The success rate after a first procedure was 75%, 15 patients benefiting subsequently from an auxiliary procedure (PCNL, ESWL, or flexible ureteroscopy). The average length of hospitalization was 4 ± 4.9 days (ranging between 2 days and 35 days), including two cases of sepsis. Therefore, simultaneous bilateral PCNL performed by an experienced surgeon has an efficiency and morbidity comparable to unilateral PCNL performed in separate sessions (Conort et al., 2010). A question that still does not have a unanimously accepted answer is on which part should the intervention be performed first: the technically easier one, in order to ensure a kidney without stones, with a minimally modified function, before continuing with the contralateral one, or the technically more difficult one, in order to ensure the absence of potential complications (Mulțescu et al., 2011).

Akman and coworkers comparatively analyzed the differences regarding the postoperative results after PCNL for staghorn stones with one or multiple puncture tracts. Thus, 59% of patients benefited from a single percutaneous tract, while 41% of them required multiple tracts (mean 2.42 ± 0.74). The mean operatory time and the duration of fluoroscopy were statistically significantly higher in the second group, as was the supracostal access (30.7% compared to 6.9%). The stone-free rate after a single procedure was 70.1% in group 1 compared to 81.1% in group 2. Despite the more frequent potential complications, PCNL with multiple tracts can be an efficient alternative for the management of staghorn stones (Akman et al., 2010).

Pardalidis and coworkers retrospectively analyzed the efficiency of PCNL as a primary therapy of stones located in the lower calyx. The study included 144 consecutive patients over a period of 10 years with uncomplicated lower caliceal calculi who benefited from PCNL after the failure of a single ESWL session. The stone-free rate for stones smaller than 10 mm was 95%, the success rates being 97% for those between 11 mm and 20 mm and respectively 98% for those larger than 20 mm. PCNL had an overall success rate of 96.7% at 3 months, regardless of the dimensions of the stone, with the absence of significant postoperative complications (Pardalidis et al., 2010).

Soucy and coworkers published a retrospective analysis of their personal experience regarding PCNL for staghorn stones over a period of 15 years. The mean operatory time was 104 min, 16% of cases required multiple tracts (between 2 and 5 tracts), the most frequently approached being the lower calyx (64.1%), followed by the upper calyx (18.5%) and the middle calyx (17.4%). The stone-free rates at the moment of discharge and at 3 months were 78% and 91%, respectively (Soucy et al., 2009).

A careful selection of patients should be made in order to optimize the results of PCNL because an unfavorable result is more probable in patients with large, multiple, or staghorn stones (Alobaidy et al., 2011).

The success rate of percutaneous nephrolithotomy can also be influenced by the source of lithotripsy used. In a study conducted by Zhu et al. (2010), the use of the Swiss Lithoclast Master (Fig. 3.88) and of the low-power Ho:YAG laser (Fig. 3.89) led to a higher success rate compared to the use of other lithotripsy sources.

The exposure to irradiation should not be forgotten when analyzing the results and in an attempt to optimize the procedure. Puncturing under fluoroscopic control with the aid of ultrasonographic guidance in PCNL increases the maneuver's accuracy and decreases exposure of the surgical team and patient to X-rays (Agrawal et al., 2011).

Due to the reduced dimensions of the access tract and difficult manipulation of the lithiasic fragments through this tract, microperc is based on the principle "break and leave," similar to that from the intrarenal retrograde approach (Armagan et al., 2013).

In addition to the advantage provided by the low risk of bleeding, miniaturized percutaneous techniques seem to offer significantly diminished pain, as well as a shorter duration of hospitalization (Sabnis et al., 2012).

Although additional data are necessary in order to evaluate the efficiency of the ultraminiperc and microperc approach, the initial results are promising.

The person who imagined the ultraminiperc approach reports a success rate at 1 day and at 1 month of 88.9% and 97.2%, respectively (Desai et al., 2013). Complications were identified in 16.7% of cases: sepsis in 5.6% (grade 2 in the Clavien classification), urinary leakage in 2.8% (Clavien grade 3a), and fever in 8.3% (Clavien grade 2). No patient required blood transfusions.

For microperc, Armagan and coworkers reported a success rate of 93% for medium-sized calculi, of which 83% were stone-free and 10% only with clinically insignificant residual fragments. Conversion to miniperc was necessary in only 10% of these patients (Armagan et al., 2013).

3.14.2 Results of Flexible Nephroscopy

Regarding flexible nephroscopy, its main benefits in the treatment of lithiasic pathology are represented by a reduction in the need for performing multiple and/or supracostal percutaneous tracts.

Netto and coworkers analyzed the rate of complications according to the particularities of the access tract in 199 patients with percutaneous interventions for staghorn lithiasis. Upper caliceal puncture was performed in 13.4% of cases, middle or lower caliceal puncture in 58.8% of cases, and multiple tracts were performed in 27.7% of patients. The overall rate of complications was 28.5%: 25% in those with upper caliceal puncture, 21.4% in those with middle or lower caliceal puncture, and 45.4% in those with multiple percutaneous tracts. Thoracic complications (pneumothorax and hydrothorax) occurred in 1.7% of cases, one of them with a supracostal access. Also, bleedings requiring blood transfusions were recorded much more frequently in the group of patients with multiple percutaneous tracts (Netto et al., 2005).

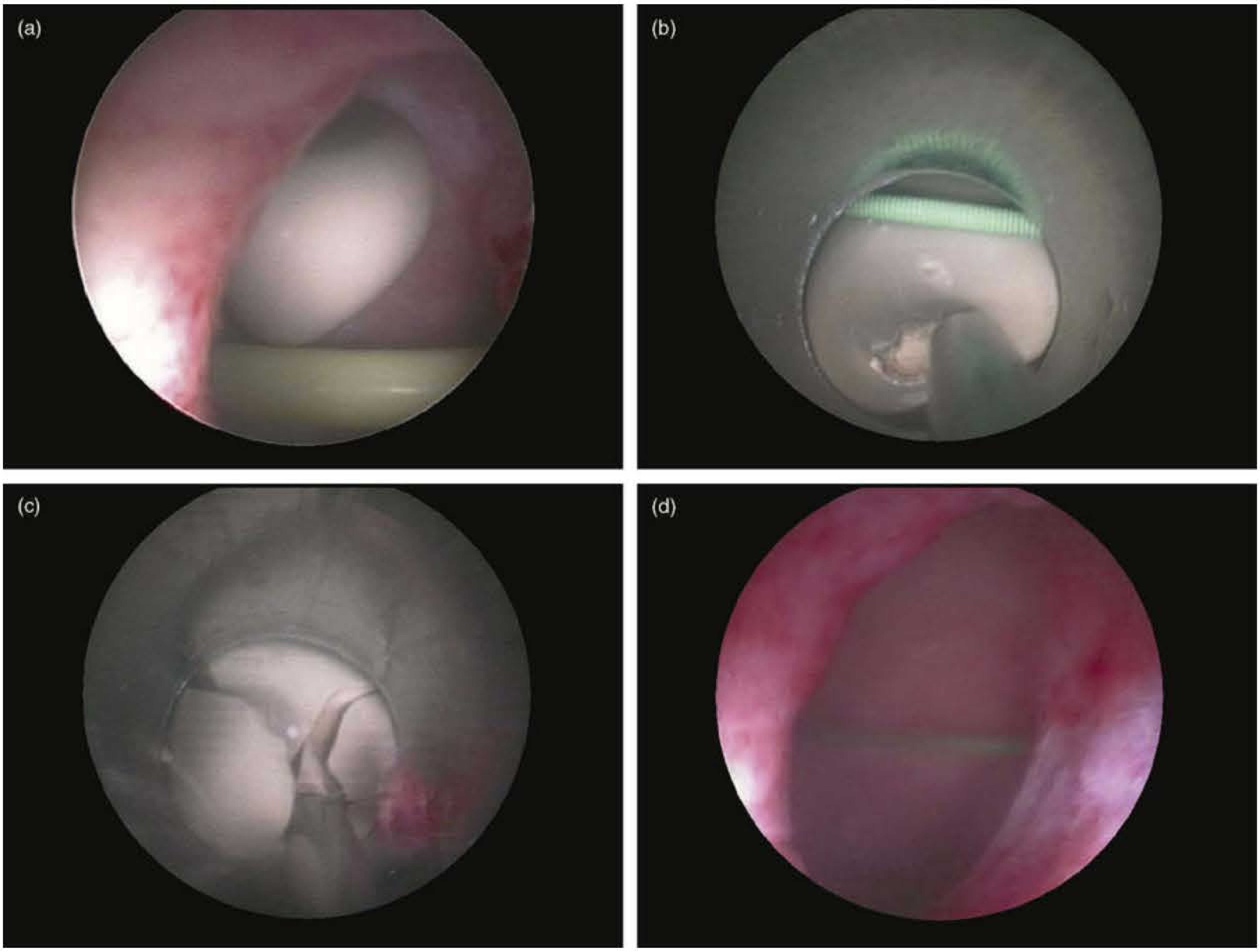

FIGURE 3.88 **Ballistic lithotripsy of a pyelic stone (a–c) and a stone-free aspect at the end of the intervention (d).**

Munver and Preminger evaluated the morbidity associated with performing 300 access tracts during percutaneous interventions for upper urinary tract pathology: 98 supracostal and 202 subcostal. A rate of complications of 16.3% was reported for the first category of patients, compared to only 4.5% for the second. Also, seven of the eight patients who developed intrathoracic complications presented supracostal access tracts (Munver et al., 2001). A significantly higher rate of postoperative pain correlated with breathing was reported in patients in whom supracostal access was used (35% compared to 5% in those with intracostal punctures) (Radecka et al., 2003).

All these data published in the literature demonstrate the utility of flexible nephroscopy. By reducing the number of tracts used and avoiding supracostal access (Fig. 3.90), this method contributes to the reduction in associated morbidity and increases the success rate of percutaneous interventions (Merhej et al., 1998).

In a study which included 95 patients with staghorn or multiple pyelocaliceal lithiasis treated percutaneously using the flexible nephroscope (associated or not with the rigid one) and electrohydraulic lithotripsy, Geavlete and coworkers reported a success rate of 95.7%. Performing a second puncture tract was necessary in only five of these cases (Geavlete et al., 2007). Similarly, in a group of 52 staghorn calculi approached by flexible nephroscopy, Wong reported a success rate of 96.2%, 82.7% of these being treated successfully using a single percutaneous access tract (Wong and Leveillee, 2002).

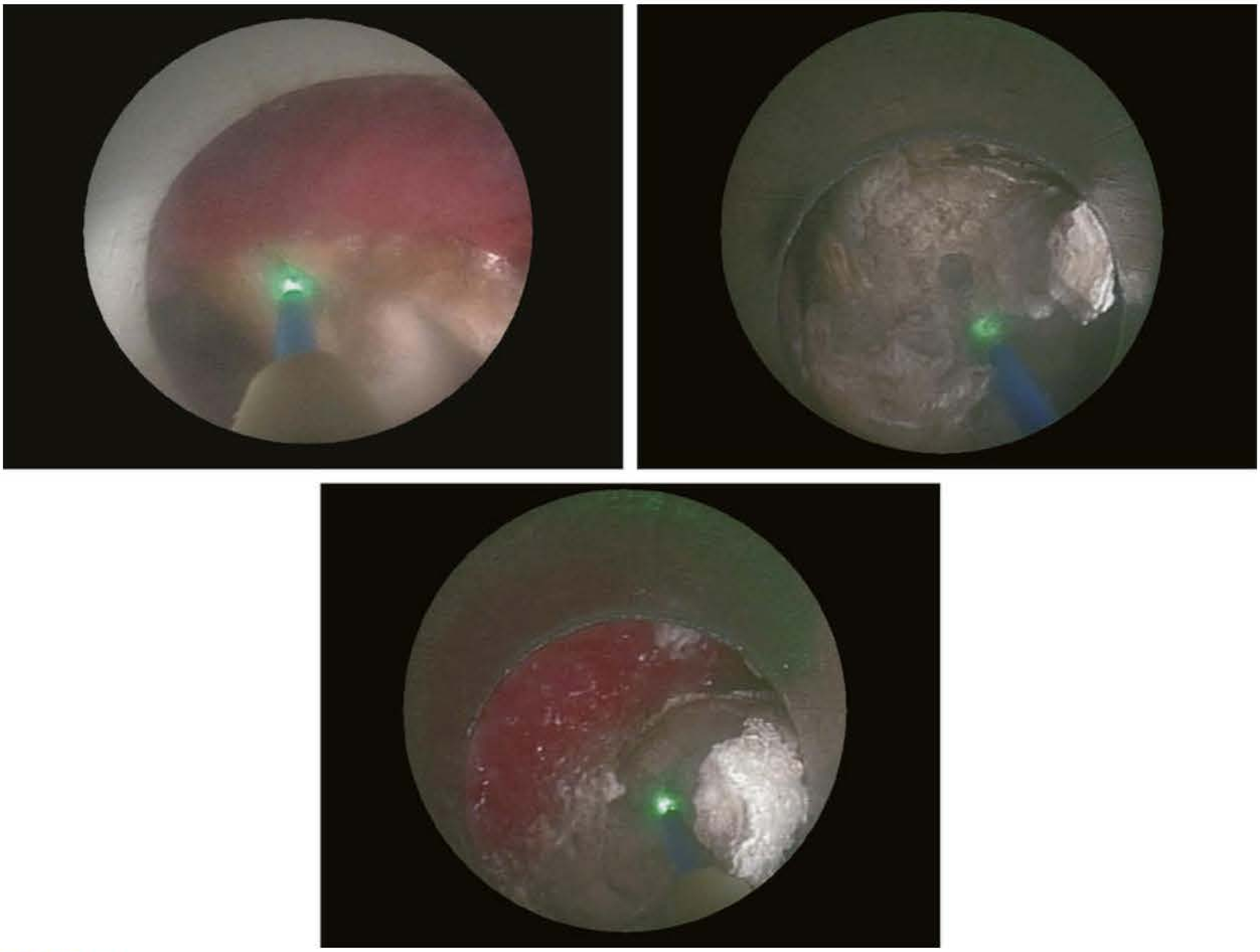

FIGURE 3.89 **Holmium laser lithotripsy of a lower caliceal stone.**

In the literature, the rate of additional tracts during the percutaneous treatment of staghorn lithiasis varies between 5.2% and 78% (Lee et al., 1987b; Newmark et al., 1995; Merhej et al., 1998; Wong and Leveillee, 2002; Geavlete et al., 2007), these differences being explained by the different preferences of the authors regarding the use of flexible nephroscopy (Lingeman et al., 2007).

Even though some authors consider that percutaneous interventions using multiple or supracostal tracts have an acceptable safety (Yadav et al., 2006; Hegarty and Desai, 2006), the meta-analyses demonstrate a higher rate of complications, many of these requiring active measures (blood transfusions, pleural drainage, etc.). These authors consider that flexible nephroscopy takes more intraoperative time and that in case of bleeding, the decreased visibility may require postponing the intervention. They prefer the percutaneous approach with multiple tracts, considering it to be quicker and frequently allowing to extract the entire lithiasic mass in a single intervention, but they admit the higher rates of associated complications, as well as the need for a longer hospitalization (Hegarty and Desai, 2006).

Due to the possibility of direct visual inspection of the pyelocaliceal system, flexible nephroscopy reduces the incidence of lithiasic remnants after percutaneous treatment (Wong, 1998; Geavlete et al., 2005).

Denstedt et al. (1991), studying 29 patients with voluminous lithiasis with combined ESWL and percutaneous nephrolithotomy treatment, remarked the overestimation of the stone-free rates by 35% and 17% through simple reno-vesical radiography and CT, respectively, compared to the results obtained by flexible nephroscopy.

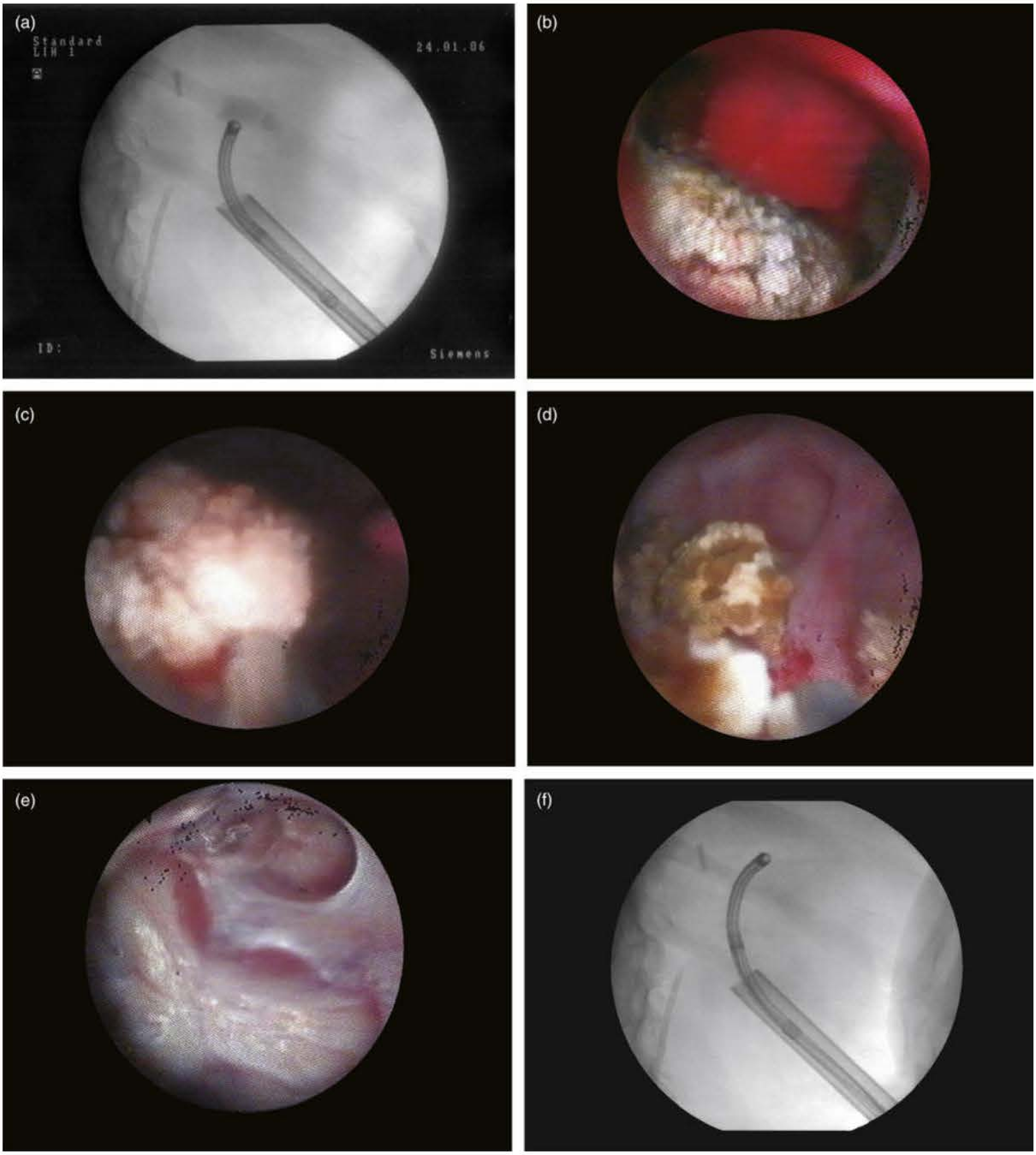

FIGURE 3.90 **Flexible nephroscopic approach of upper caliceal stones using a lower, infracostal caliceal percutaneous tract (a, b), with electrohydraulic lithotripsy (c, d) and stone-free aspect at the end of the intervention (e, f).**

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CHAPTER

4

Percutaneous Approach of Caliceal Diverticula

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4.1 GENERALITIES

(Pyelo)caliceal diverticula are intrarenal cavities covered by urothelium, without secretion, which are passively filled with urine coming from the intrarenal tracts, with which they communicate through a neck.

The epidemiology, etiopathogenic theories, and classification of diverticula, as well as the characteristics of intradiverticular lithiasis, have been amply described in the section dedicated to retrograde ureteroscopic approach. In this chapter we will try to detail the characteristics of the percutaneous approach of this pathology.

Most caliceal diverticula are asymptomatic (Rapp and Gerber, 2004), usually being discovered by chance. Some patients with caliceal diverticula may present lumbar pain, hematuria, or pyuria. The incidence of intradiverticular lithiasis varies between 9.5% and 54% in patient groups reported in the literature (Middleton and Pfister, 1974; Timmons et al., 1975; Yow and Bunts, 1995; Matlaga et al., 2006).

4.2 INDICATIONS

Patients with chronic pain, recurrent urinary tract infections, macroscopic hematuria, or progressive destruction of the renal parenchyma have an indication for surgical treatment, regardless of the existence or not of intradiverticular calculi (Geavlete et al., 2004). The presence of lithiasis does not represent an indication for surgical intervention in the absence of the other signs and symptoms mentioned previously.

Choosing the type of intervention depends on the position of the diverticulum, its size, the presence and size of lithiasis, the available equipment, the patient's preference, and the surgeon's experience.

Percutaneous approach is probably the most frequently used method for the minimally invasive treatment of caliceal diverticula (Shalhav et al., 1998; Kontak et al., 2007; Geavlete et al., 2007). Although direct access into the diverticulum is usually used, the indirect one may be applied in selected cases.

Percutaneous interventions are generally reserved for symptomatic diverticula larger than 1.5 cm, with intradiverticular lithiasis (Monga and Beeman, 2004). Smaller ones may be difficult to approach percutaneously, benefiting from other minimally invasive methods such as flexible ureteropyeloscopy. The retrograde approach is also preferred for caliceal diverticula situated anteriorly, which are difficult to approach percutaneously (Leveille and Bird, 2007).

These diverticula, especially if they are voluminous and have a large intradiverticular lithiasic mass, can also be accessed through the indirect percutaneous approach. The indirect approach is also reserved for cases of failed direct intervention, for those associated with other pyelocaliceal calculi (Shalhav et al., 1998), or for those with upper caliceal localization, which frequently requires creating supracostal access tracts (Geavlete et al., 2004). In patients from the latter category (especially those who require performing the puncture above the 11th rib), the indirect percutaneous approach can also be a safer therapeutic alternative.

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The Guy lithiasis score, with implications in predicting the success of percutaneous interventions, places patients with intradiverticular lithiasis in class III or IV, along with those with multiple lithiasis on kidneys with anatomical anomalies or with partial staghorn calculi (Thomas et al., 2011).

4.3 TECHNIQUES

4.3.1 Direct Percutaneous Approach

4.3.1.1 *Positioning the Patient*

The direct percutaneous approach of caliceal diverticula is usually performed with the patient in the prone position, with the ipsilateral side raised by 30°.

4.3.1.2 *Placing the Ureteral Catheter*

Using a cystoscope and under fluoroscopic control, a ureteral catheter is placed, through which a contrast agent will be injected until opacification of the diverticulum is achieved (Fig. 4.1). Once placed, the ureteral catheter will be fixed to the urethro-vesical catheter with a thread.

4.3.1.3 *Puncture of the Diverticulum*

The puncture will be performed with an 18-gauge needle directly into the diverticular cavity (Fig. 4.2), opacified along with the pyelocaliceal system by injecting contrast agent through the ureteral catheter.

Some authors perform the puncture in patients with radiopaque lithiasis directly into the lithiasis, without prior opacification (Krambeck and Lingeman, 2009).

If the diverticulum's opacification is insufficient (usually in the case of very tight necks), the puncture can be performed under ultrasonographic control (Van Sonnenberg et al., 1992).

Externalization of urine through the needle certifies a correct puncture.

4.3.1.4 *Creating the Percutaneous Tract*

Once the diverticular cavity is punctured, a guidewire with the distal part in the shape of the letter J will be inserted on the needle (Fig. 4.3).

The tract's dilation is performed through the needle with fascial dilators with progressive caliber, 8–10 F, and then with a balloon or Alken-type dilator. At the end, a 28–30 F Amplatz sheath is placed over the dilators, up to the level of the diverticular cavity. An alternative of the method has also been described, in which dilation is achieved in the immediate proximity of the diverticulum, with only the metallic guidewire entering the cavity. After extraction of the dilators, the nephroscope is inserted through the Amplatz sheath and, with the help of an alligator forceps, the puncture orifice of the diverticulum is widened. The nephroscope will be advanced into the cavity, followed by the

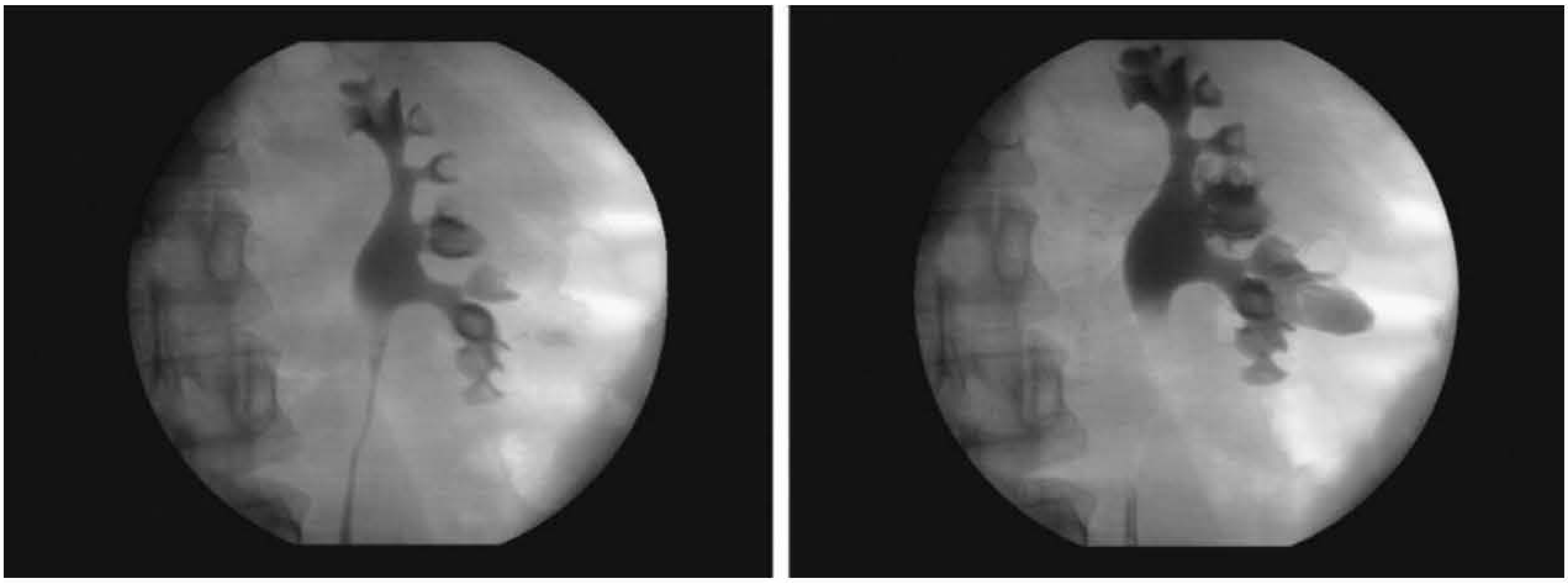

FIGURE 4.1 **Identifying a lower caliceal diverticulum by retrograde injection of contrast agent.**

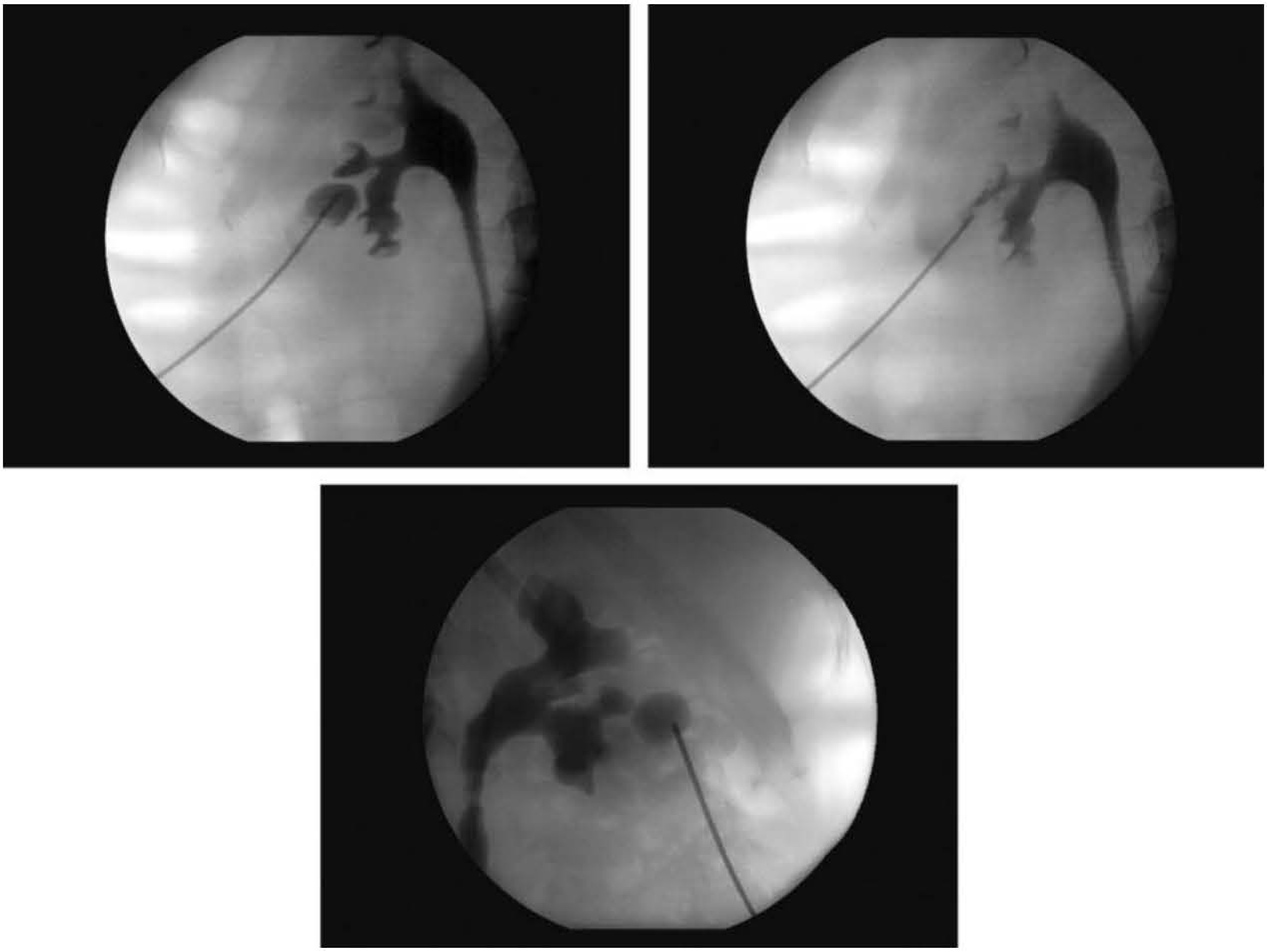

FIGURE 4.2 Direct puncture of the caliceal diverticula.

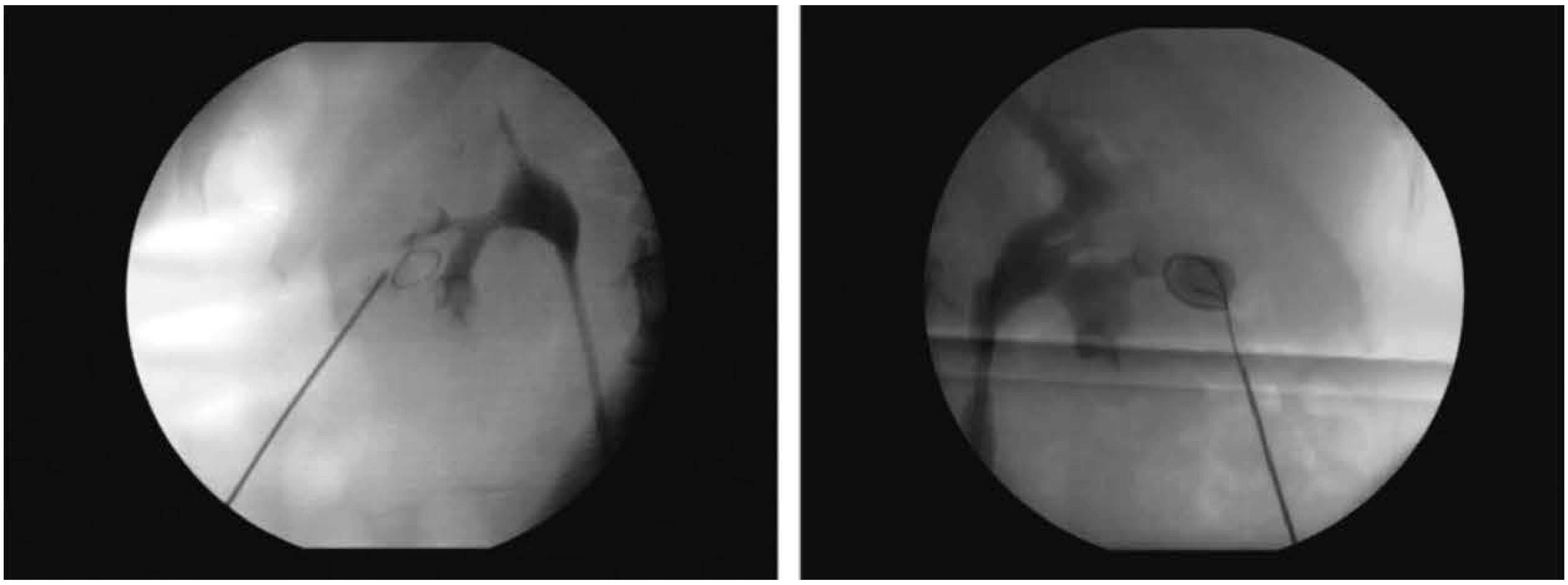

FIGURE 4.3 Placing a guidewire at the level of the diverticular cavity.

Amplatz sheath, which will slide on the endoscope. This method is especially recommended in the case of smaller diverticula (Krambeck and Lingeman, 2009).

4.3.1.5 *The Extraction of Intradiverticular Calculi*

The calculi will be extracted either in one piece with the forceps through the Amplatz sheath (Fig. 4.4) or, in the case of larger ones, after ballistic, laser, ultrasonic, or electrohydraulic fragmentation.

4.3.1.6 *Management of the Diverticular Cavity and the Neck*

Different strategies have been proposed for the management of the diverticular cavity or the diverticular neck.

One variant involves the identification of the diverticular neck, its progressive dilation or recalibration by incision, followed by placing a transdiverticular nephrostomy tube, up to the renal pelvis (Jones et al., 1991; Bellman et al., 1993; Shalhav et al., 1998). Sometimes, methylene blue can be injected through the ureteral catheter for an easier and safer identification of the neck (Fig. 4.5).

Also due to safety concerns, a guidewire can be placed antegradely up to the pyelocaliceal system (Fig. 4.6), and the laser or electric incision will be made along the guidewire (Fig. 4.7).

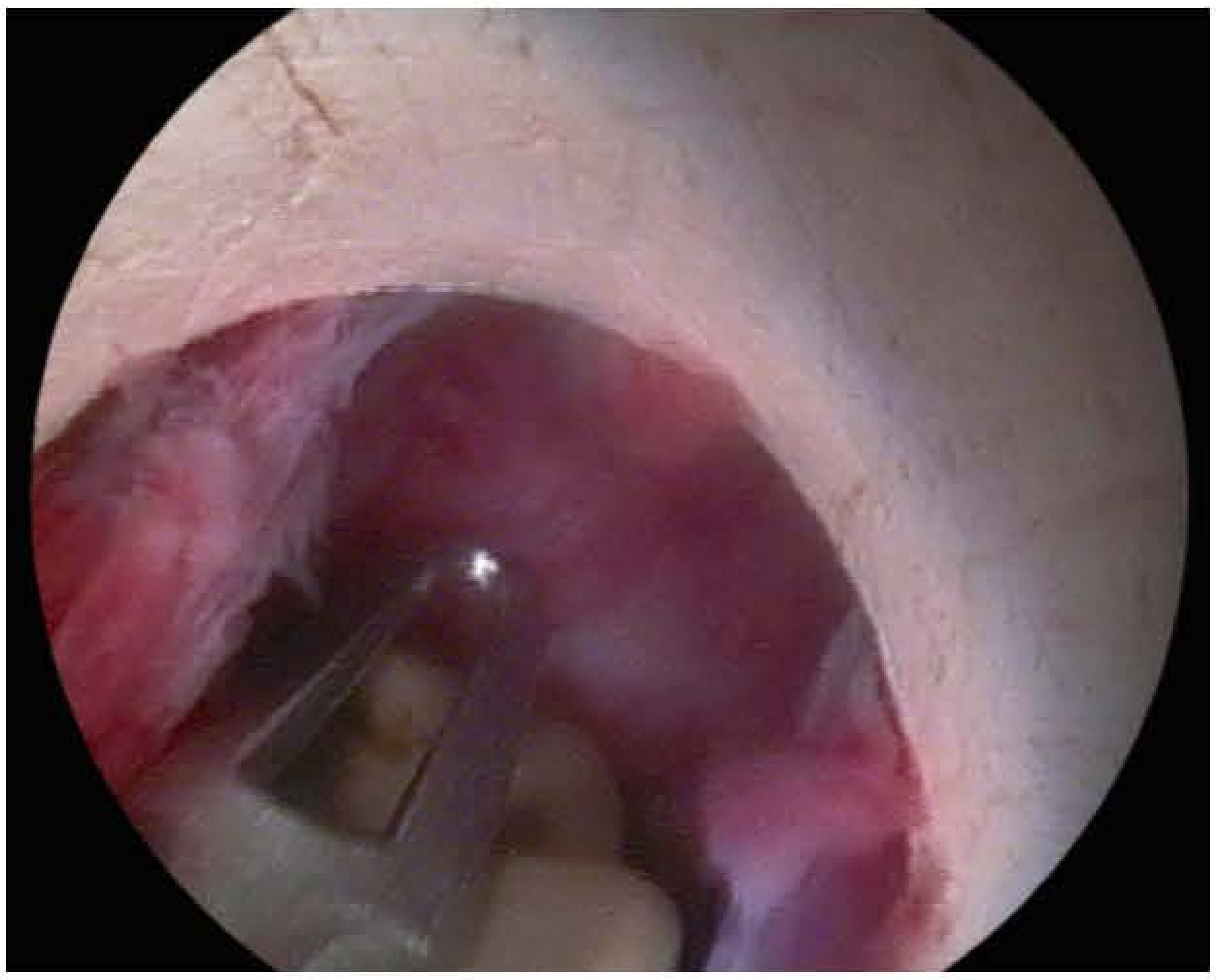

FIGURE 4.4 **Extraction of the intradiverticular lithiasis with the forceps.**

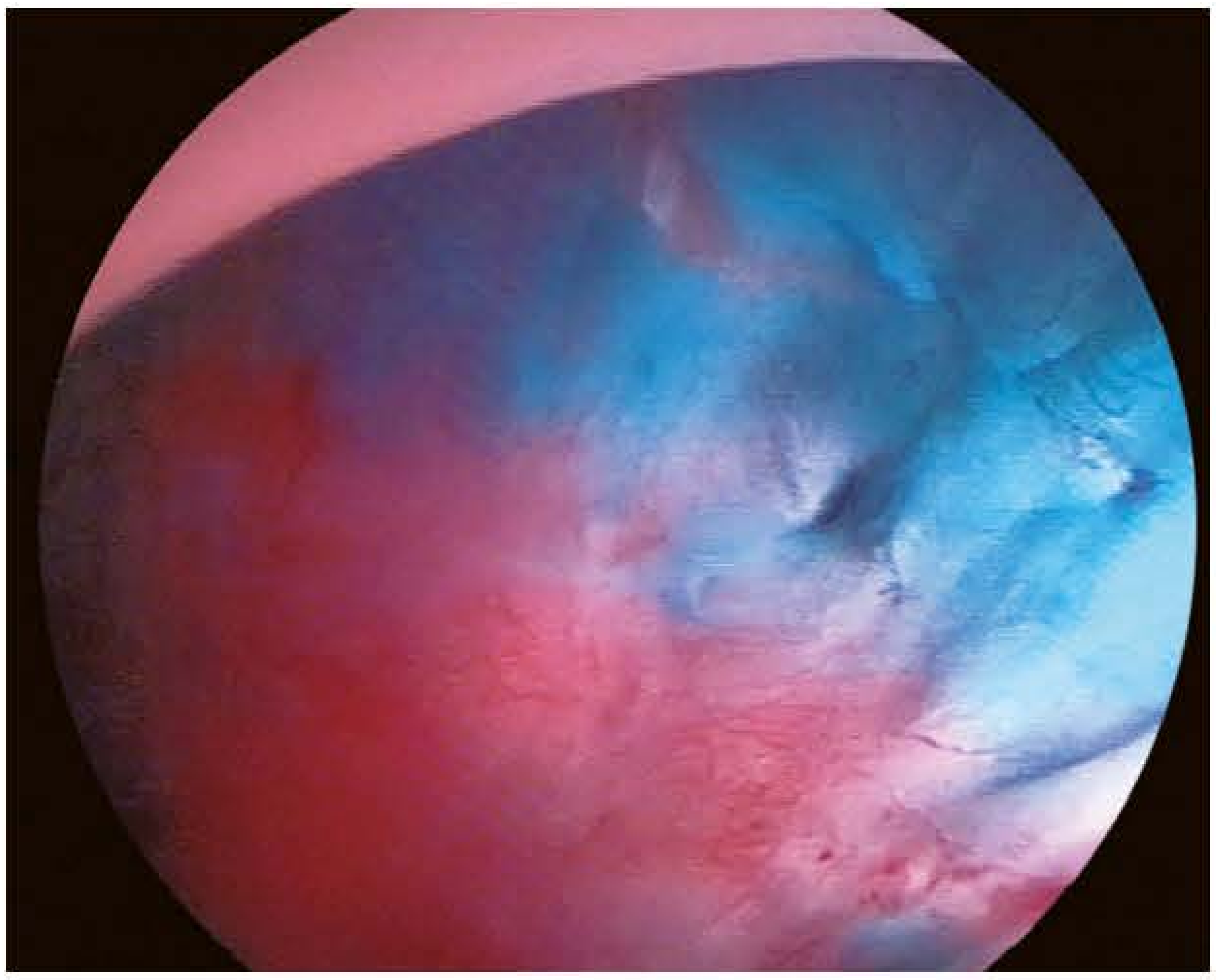

FIGURE 4.5 **Identifying the diverticular neck by injecting methylene blue.**

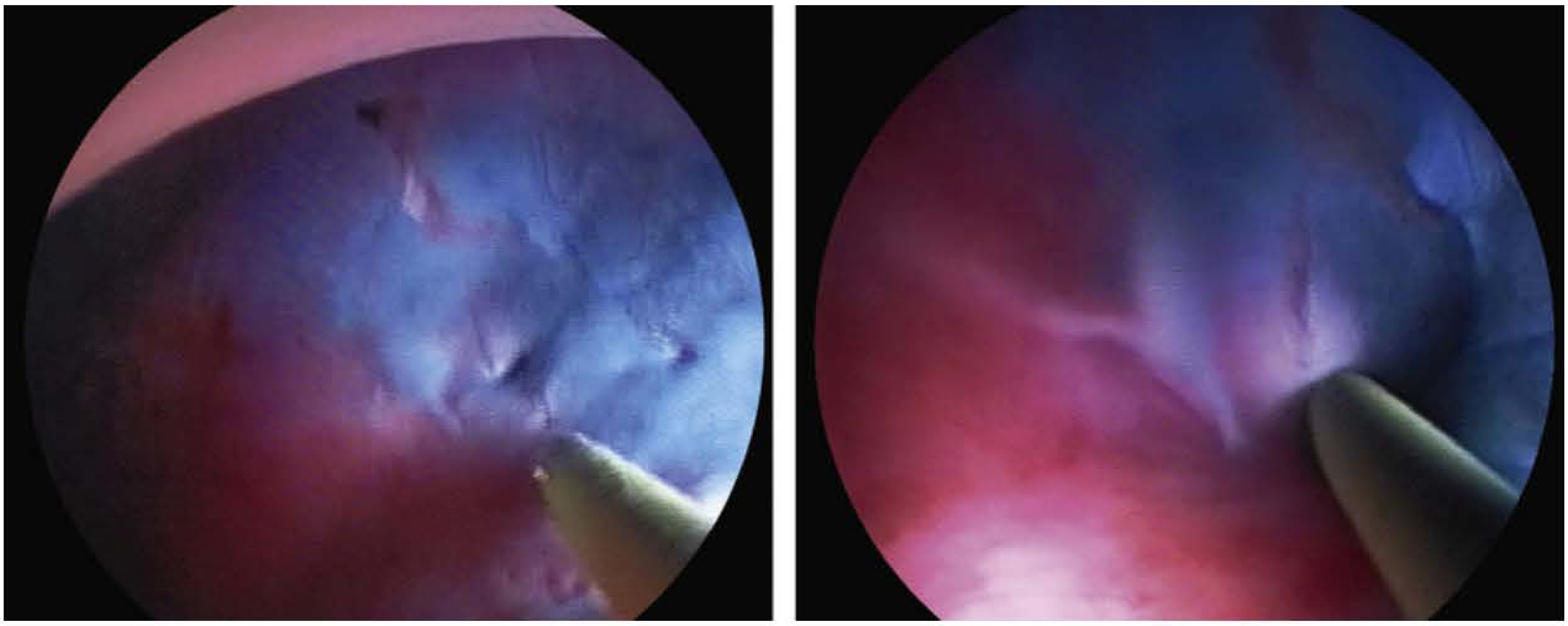

FIGURE 4.6 **Placing a guidewire through the neck with the help of a catheter.**

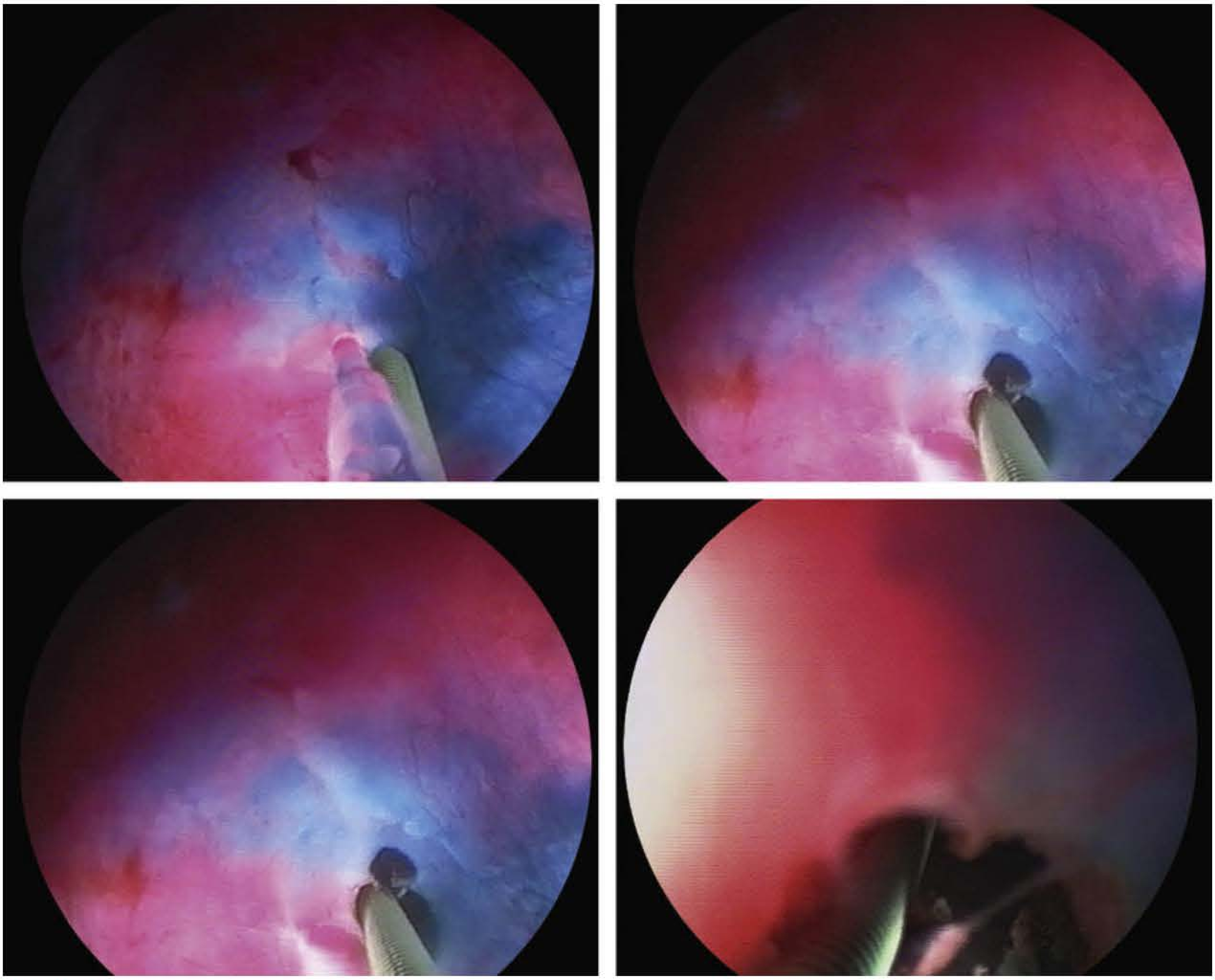

FIGURE 4.7 **Recalibration of the diverticular neck by laser incision.**

If the neck cannot be identified, the creation of a neo-neck and the placement of the nephrostomy tube in the same manner as the one described earlier have been proposed (Auge et al., 2002a,b; Al-Basam et al., 2000). However, both variants have an increased risk of complications (especially bleeding).

The creation of a neo-neck is not recommended in the case of anterior diverticula, to avoid perforating the normal renal parenchyma in an attempt to obtain communication with the pyelocaliceal system.

Some authors do not identify the neck, but perform a systematic destruction of the intradiverticular urothelium either through roller electrocoagulation (Krambeck and Lingeman, 2009), Bugbee electrode, or laser photocoagulation. The nephrostomy tube will have its proximal end abandoned in the diverticular cavity. In the case of small diverticula, the nephrostomy tube is almost always depositioned due to the respiratory movements, being transformed into a perirenal drainage.

Destruction of the intradiverticular urothelium is contested by some authors, on the premise that it is nonsecretory (Batter and Dretler, 1997). Hulbert et al. (1986) suggest that the simple mechanical trauma of creating the percutaneous tract is enough to determine the disappearance of the diverticular cavity. However, most authors also recommend fulguration of the intradiverticular epithelium during percutaneous interventions.

4.3.1.7 Placing the Nephrostomy Tube

The nephrostomy tube can be placed transdiverticularly, up to the renal pelvis, or abandoned in the diverticular cavity.

4.3.2 Indirect Percutaneous Approach

In the case of the indirect approach, the percutaneous access is usually achieved in the lower calyx. The position of the neck is identified radiologically by injecting the contrast agent through the ureteral catheter and then visually with a flexible nephroscope. Once the distal end of the nephroscope is aligned with the neck, a guidewire is inserted into the diverticular cavity. Recalibration of the neck is obtained by dilation with the balloon probe, laser, or electric incision.

The use of the Ho:YAG laser is preferred due to its superior safety profile, having a tissue penetrability of only 0.5–1 mm, compared to 4–5 mm for the Nd:YAG laser. This type of laser can also be used in the next step of the intervention, for lithotripsy of intradiverticular calculi.

Multiple superficial incisions are made at 3, 6, 9, and 12 o'clock, with a reduced risk of injuring the interlobar artery with consecutive bleeding compared to a single profound incision (Monga and Beeman, 2004). These incisions must involve only the mucosa and submucosa.

After gaining intradiverticular access, the potential lithiasis is extracted, in a single piece or after fragmentation. The use of a flexible endoscope limits lithotripsy alternatives to laser or electrohydraulic. Also, flexible basket probes and forceps will have to be used.

4.4 COMPLICATIONS

The incidents and complications for this type of intervention (Table 4.1) are divided into those which are common to all percutaneous interventions or disease-specific.

An intraoperative incident is represented by the loss of the percutaneous access tract. This is perhaps more frequent in the case of diverticular approaches than in that of percutaneous nephrolithotomy, due to the reduced space in the diverticular cavity. This can cause the loss of the tract during the dilation maneuvers.

In cases in which diverticular neck incision is performed, there is a risk of bleeding through damage to the interlobar artery, due to their proximity to the caliceal infundibulum. Other complications include septic ones, from pyelonephritis to sepsis, especially in cases of improper case selection, and in patients who presented infected urine before the intervention (Leveille and Bird, 2007).

TABLE 4.1 The Rate of Complications Associated With the Percutaneous Approach of Caliceal Diverticula

Author	No. of patients	Major complications
Hulbert et al. (1986)	10	0
Jones et al. (1991)	14	3
Ellis et al. (1991)	10	1
Hendrikx et al. (1992)	16	3
Lagha et al. (1993)	19	0
Donnellan et al. (1999)	21	0
Shalhav et al. (1998)	19	2
Monga et al. (2000)	26	2
Lancini et al. (2000)	40	0
Al-Basam et al. (2000)	18	1
Auge et al. (2002a, b)	22	3
Landry et al. (2002)	31	0
Kim et al. (2005)	21	0
Staios et al. (2007)	22	0

TABLE 4.2 The Results of the Percutaneous Approach of Caliceal Diverticula

Author	No. of patients	"Stonefree" (%)	Complete resolution of symptoms	Cavity obliterations
Hulbert et al. (1986)	10	70	–	66
Jones et al. (1991)	14	100	100	–
Ellis et al. (1991)	10	100	70	75
Hendrikx et al. (1992)	16	80	80	–
Lagha et al. (1993)	19	84	94	72
Donnellan et al. (1999)	21	81	80	85
Shalhav et al. (1998)	19	95	100	80
Monga et al. (2000)	26	93	85	76
Lancini et al. (2000)	40	95	100	87.5
Al-Basam et al. (2000)	18	89	–	–
Auge et al. (2002a,b)	22	78	86	–
Landry et al. (2002)	31	84	88	68
Kim et al. (2005)	21	85.7	100	100
Staios et al. (2007)	22	87	–	80

4.5 RESULTS

The success of percutaneous interventions for pyelocaliceal diverticula, similar to the retrograde approach, can be defined in several ways: complete extraction of calculi (stonefree), complete absence of symptoms, or complete obliteration of the diverticular cavity (Table 4.2). The first two parameters are probably the most important, obtaining a wide communication between the pyelocaliceal system and the cavity being sufficient for many authors (Geavlete et al., 2007).

The results of the method, with all its variations, can be considered as being very good, with rates varying between 70% and 100% for "stonefree" and complete disappearance of symptoms, and between 66% and 100% for complete obliteration of the cavity.

Moreover, long-term studies demonstrate a stable resolution of symptoms in time.

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CHAPTER

5

Percutaneous Approach in Pyeloureteral Junction Stenosis

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5.1 GENERALITIES

Pyeloureteral junction (UPJ) stenosis represents a pathological entity which has been known and studied for more than a century. The therapeutic alternatives for this condition cover a large spectrum, from minimally invasive methods (such as placing ureteral stents) to open surgery. All these therapeutic options require a deep knowledge of the indications and risks of each method.

The first treatment method described for UPJ stenosis was the open surgical one: pyeloplasty. The evolution of technique and of treatment methods determined the emergence of less invasive alternative endoscopic treatment options, with very good results and a shorter hospitalization period, the patients also benefiting from a much quicker social reintegration.

The basis of endoscopic treatment was introduced in 1943 by Davis, who first performed "intubated ureterotomy" as a method for treating high ureteral and UPJ stenoses. Although this treatment method was the attribute of classic open surgery, the principle of intubated ureterotomy, meaning the incision of the narrowed ureteral or junction segment, was the basis of the endoscopic treatment of upper urinary tract stenoses. Since then, multiple endoscopic treatment possibilities have been imagined, which by antegrade or retrograde approach allowed for the incision of the stenotic area followed by splinting.

The indications for the surgical approach of an upper urinary tract stenosis are still a subject of debate in the world of urology. Moreover, the type of surgical approach (endoscopic or surgical), as well as the moment of initiating treatment, is a cause for controversy within urology congresses.

Although the current preference of many patients and urologists is the endoscopic approach, this is not always possible. Most authors recommend immediate treatment for acquired stenosis, while there are controversies regarding the moment of initiating therapy for congenital stenosis.

The etiology of UPJ stenosis is not completely known despite the multiple embryologic, anatomic, functional, and histological studies that have been performed. Although most cases of UPJ stenosis are probably congenital, their clinical expression is often observed at older ages.

According to their mechanism of occurring, UPJ stenoses are divided into congenital and acquired.

5.1.1 Congenital UPJ Stenosis

Congenital UPJ stenosis is an intrinsic condition, represented by a defect of the ureteral musculature. Thus, an aperistaltic ureteral segment may appear (similar to congenital megaureter). Histopathological studies have shown the replacement of the circular muscle fibers, normally present at this level, with abnormal longitudinal muscle fibers and fibrous tissue (Hanna et al., 1976). This may be secondary to the interruption in the development of the circular musculature at the UPJ level or to alteration of the collagen fibers (Hanna, 2000). The muscle fibers become scattered, which results in a discontinuity of their contraction. In these circumstances, the peristaltic wave necessary for the propulsion of urine from the renal pelvis to the ureter cannot form.

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Intrinsic obstruction of the UPJ may occur as a result of the thickening of the ureteral muscularis and mucosa, similar to a valve (Maizels and Stephens, 1980). The presence of these "valves" may cause ureteral angulation, so that its insertion in the renal pelvis can occur more proximally. As a result, the lowest part of the renal pelvis is not properly drained, the aspect of "high insertion" of the ureteral ostium actually being a secondary phenomenon (Kelalis, 1976).

In certain cases, the high insertion of the ureter is actually the primary cause of obstruction, being more frequently associated with renal ectopia or other fusion anomalies (Das and Amar, 1984).

Even today there are many controversies regarding the potential role of aberrant vessels in the etiology of UPJ obstruction. These segmental vessels, which are improperly called aberrant, are branches of the renal artery or even of the aorta and are actually anatomical variants (Stephens, 1982). They can cross the ureter, having an abnormal trajectory. The highest probability of such vessels having repercussions on the urinary tract is their association with other intrinsic lesions of the UPJ or of the proximal ureter.

Some authors emphasize the fact that the UPJ syndrome is a complex pathology which is based on several etiological factors: intrinsic and extrinsic. The intrinsic factors are represented by an adynamic ureteral segment, intrinsic ureteral stenosis, and tumors. The extrinsic factors are represented by high ureteral insertion, aberrant vessels, vesicoureteral reflux, postoperative scars, and other compressive mechanisms (retroperitoneal fibrosis, etc.) (Boja, 2000).

5.1.2 Acquired UPJ Obstruction

Vesicoureteral reflux causes urinary tract dilation with its elongation, and the appearance of ureteral sinuosities and thickening. UPJ stenosis may be associated with vesicoureteral reflux, although it is difficult to specify if these anomalies coexist or if the UPJ obstruction is secondary to the reflux (Lebowitz and Johan, 1982).

5.1.3 Diagnosis of UPJ Obstruction

UPJ stenosis may become clinically manifest at any age.

The most frequent symptoms are represented by: abdominal or lumbar pain, vomiting, hematuria (sometimes caused by minor trauma), hypertension (very rare).

Paraclinical investigations may show: microscopic hematuria, pyuria, urinary infection. Radiologically, it is imperative to study the anatomy and the repercussions of the obstruction on the pyelocaliceal system. Intravenous urography was and still is the most commonly used radiological investigation. Delayed secretion and excretion on the affected side and dilation of the pyelocaliceal system are classically described (Fig. 5.1). If the ureter can be visu-

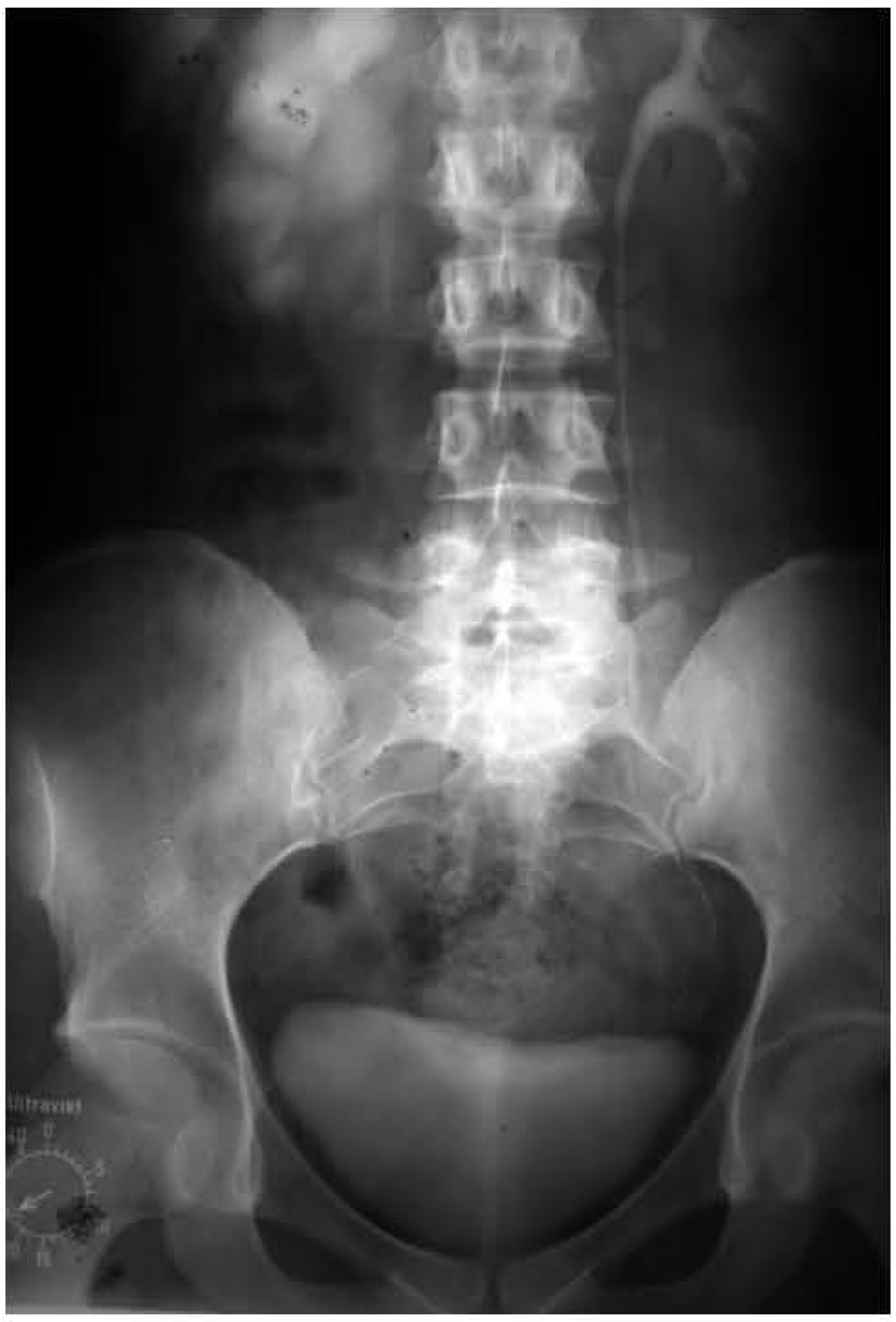


FIGURE 5.1 **Hypofunctional right kidney with delayed secretion and grade III hydronephrosis secondary to UPJ obstruction.**

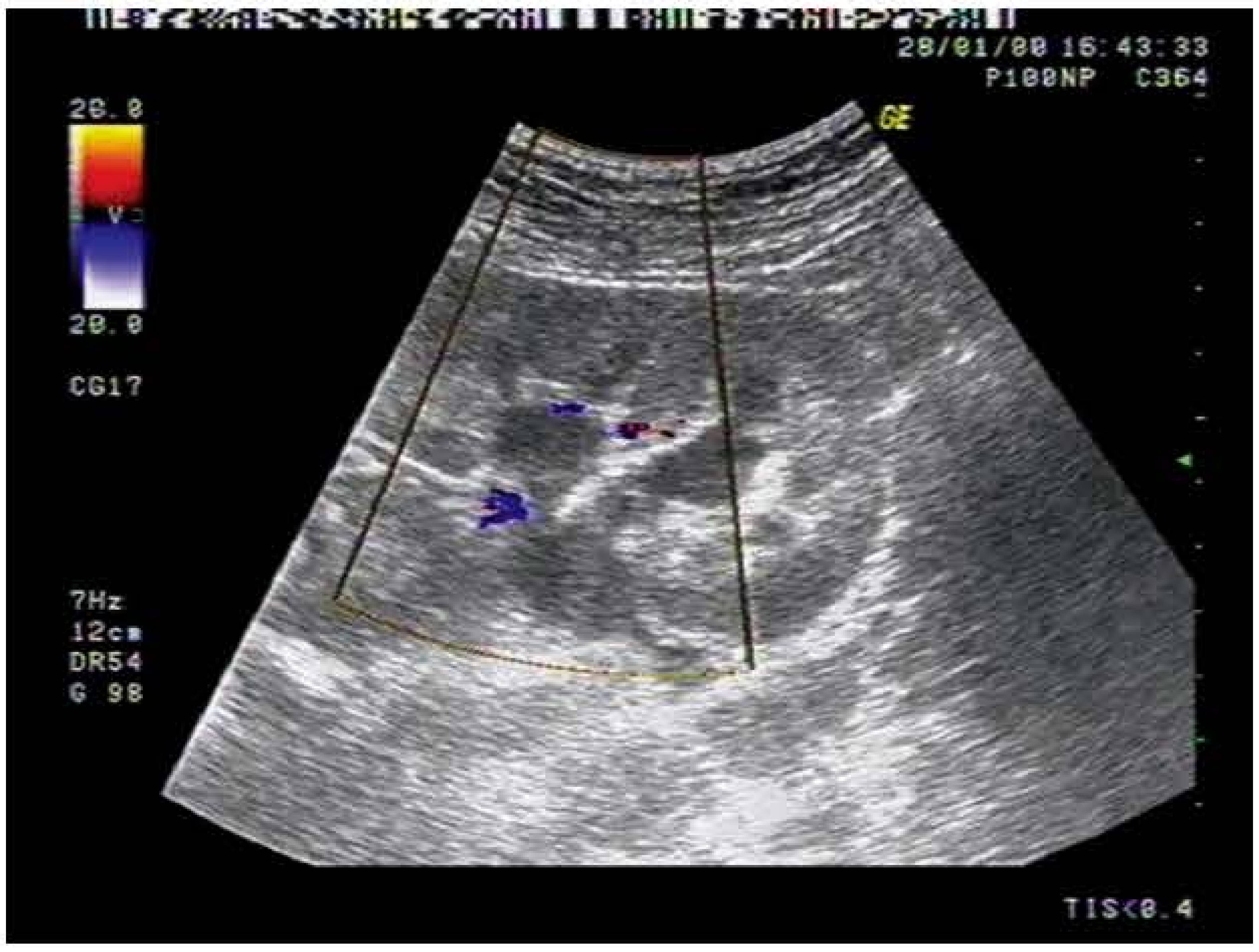


FIGURE 5.2 **Left renal ultrasonography in a patient with UPJ stenosis and grade II hydronephrosis.**

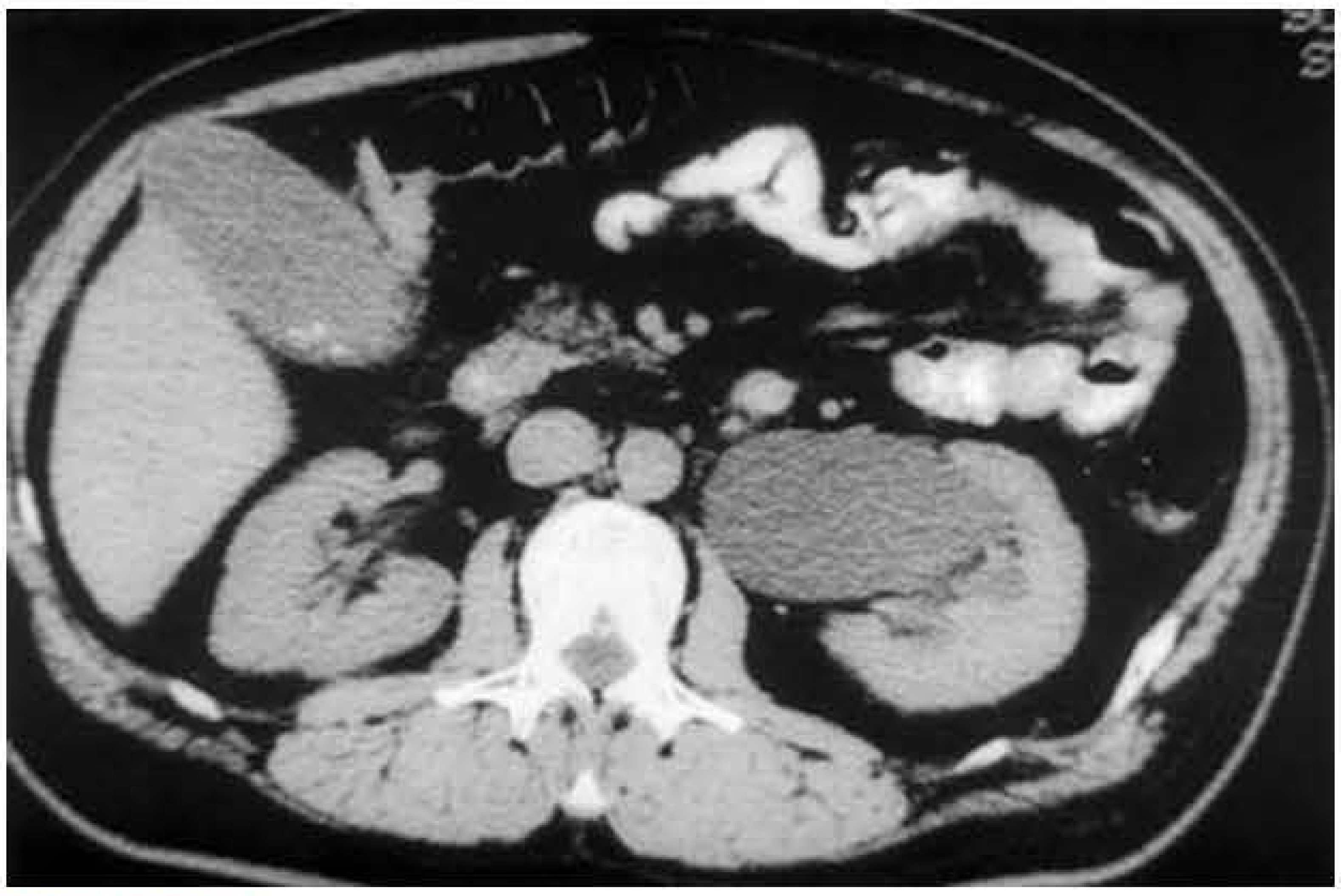


FIGURE 5.3 **CT scan aspect in a patient with left UPJ stenosis and grade II hydronephrosis.**

alized, it is normal. Alternatively, urography with diuretics may be used (furosemide 0.3–0.5 mg/kg intravenously when performing the urography).

Ultrasonography has an essential role in the initial diagnosis of urinary tract obstruction (Fig. 5.2). Also, ultrasonography is very important for patients who cannot perform urography (allergy to contrast agents, uremia, etc.). Furthermore, by calculating the resistive index, urinary tract obstruction can be diagnosed with relative accuracy (Geavlete et al., 2001a).

Endoluminal ultrasonography was initially used in gastroenterology and in cardiovascular surgery. This technique allows an accurate localization and may provide valuable information regarding blood vessels adjacent to the ureter, along with a detailed evaluation of the UPJ stenosis: size, ureteral lumen diameter.

Computed tomography provides a great deal of information regarding the renal anatomy and function, the renal collecting system, and the ureter (Vieweg et al., 1998) (Fig. 5.3). Spiral tomography with tridimensional reconstruction can show blood vessels (arterial phase), and their reconstruction provides valuable information regarding the aberrant vessels.

Equipment improvements and the evolution of software for processing the data obtained through tomography have recently allowed performance of tridimensional reconstruction. Thus, after the contrast agent is administered, the computed tomography urography (IVUCT) can be performed, which allows for a detailed evaluation of renal and urinary tract morphology (Fig. 5.4).

Magnetic resonance imaging is also a modern imaging technique. Although more rarely used, it may provide information similar to CT, sometimes with a better image quality and no patient irradiation.

Renal scintigraphy with isotopic nephrogram performed with 99mTc-DTPA (Fig. 5.5) is very useful both for the preoperative evaluation of the renal unit's function and for postoperative follow-up (improvement of renal function after removing the obstruction). Scintigraphy with 99mTc-DTPA is of great use in the variant with forced diuresis (with furosemide), being able to quantify the degree of obstruction in cases where standard studies are equivocal.

Although the diagnosis of UPJ stenosis can be established very accurately by physical examination and the paraclinical methods mentioned previously, retrograde ureteropyelography (Figs 5.6 and 5.7) has an important role in confirming the diagnosis and in accurately locating the obstruction and determining its cause (Nesbit, 1956). It is most frequently performed immediately before the intervention due to the maneuver's infective risk.

If retrograde cystoscopy cannot be performed or if it is too risky, placing a percutaneous nephrostomy may be an excellent solution, especially because it also allows performance of antegrade studies regarding the location and nature of the obstruction. Moreover, nephrostomy allows decompression of the urinary tract, with the assessment of the renal function and eventually of its recovery after decompression.

Percutaneous nephrostomy allows conduction of perfusion studies to highlight the clinical significance of a urinary tract obstruction. First described by Whitaker in 1973 and then modified in 1978, perfusion studies are performed by perfusing the renal pelvis at a flow rate of 10 cm^3/min with saline (or alternatively, with radiological contrast agent under fluoroscopic monitoring) (Whitaker, 1978). The pressure in the renal pelvis is monitored during the saline perfusion, thus allowing calculation of the pressure gradient at the stenotic level. During the evaluation, the urinary bladder is drained to prevent the increase of intravesical pressure. A renal pelvis pressure of 15–22-cm H_2O is suggestive for a functional obstruction. Pressures not included in this range do not have diagnostic significance.

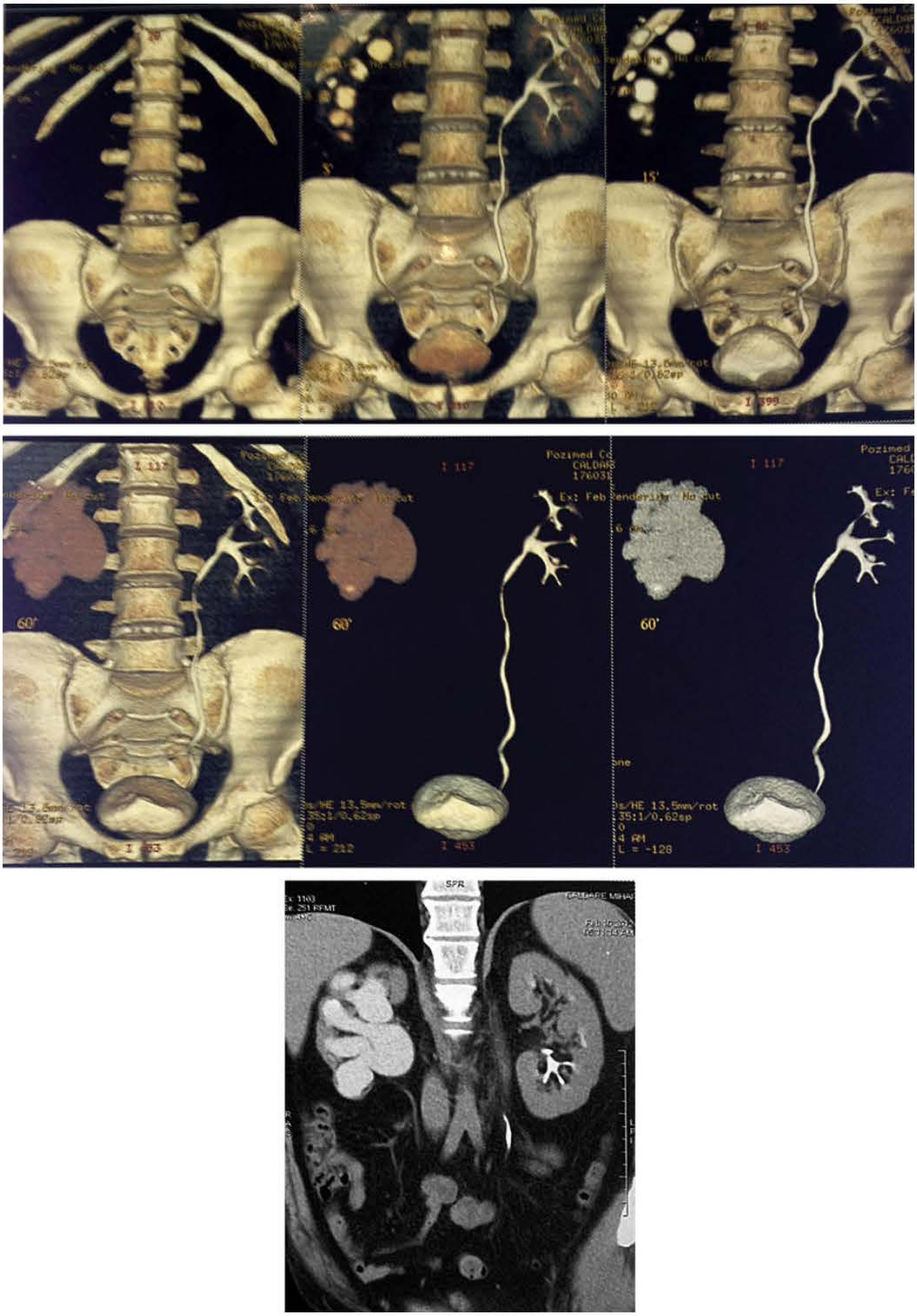
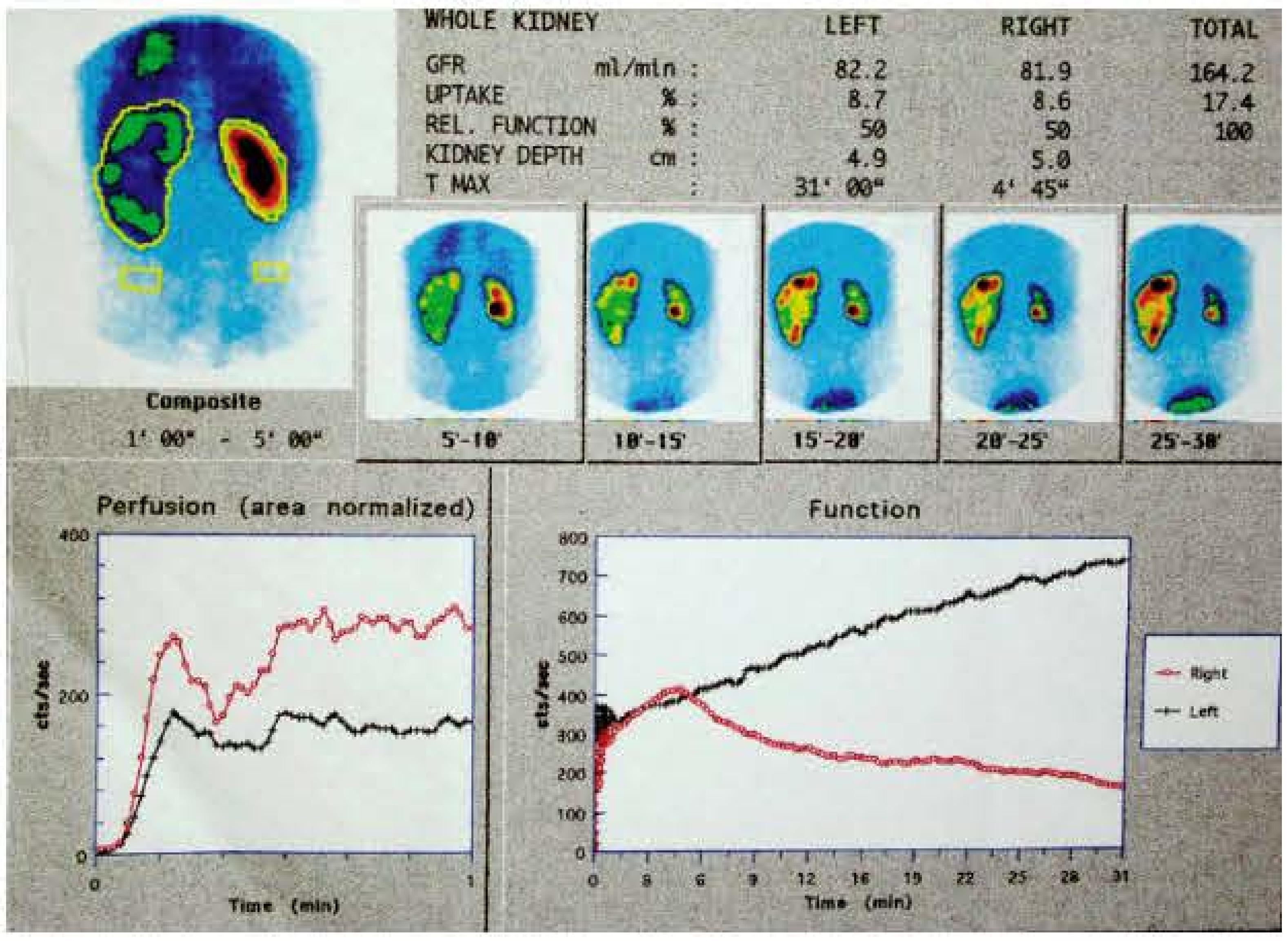


FIGURE 5.4 **IVUCT by tridimensional reconstruction: right UPJ stenosis with grade III hydronephrosis.**



WHOLE KIDNEY		LEFT	RIGHT	TOTAL
GFR	ml/min :	82.2	81.9	164.2
UPTAKE	% :	8.7	8.6	17.4
REL. FUNCTION	% :	50	50	100
KIDNEY DEPTH	cm :	4.9	5.0	
T MAX	:	31' 00"	4' 45"	

Composite
1' 00" - 5' 00"
5'-10'
10'-15'
15'-20'
20'-25'
25'-30'
Perfusion (area normalized)
400
200
0
cts/sec
0
1
Time (min)
Function
800
700
600
500
400
300
200
100
0
cts/sec
0 3 6 9 12 16 19 22 25 28 31
Time (min)
Right
Left

FIGURE 5.5 **Renal scintigraphy with isotopic nephrogram.** Hydronephrosis secondary to UPJ stenosis. Obstructive type washout curve and significant hydronephrosis in the left kidney.

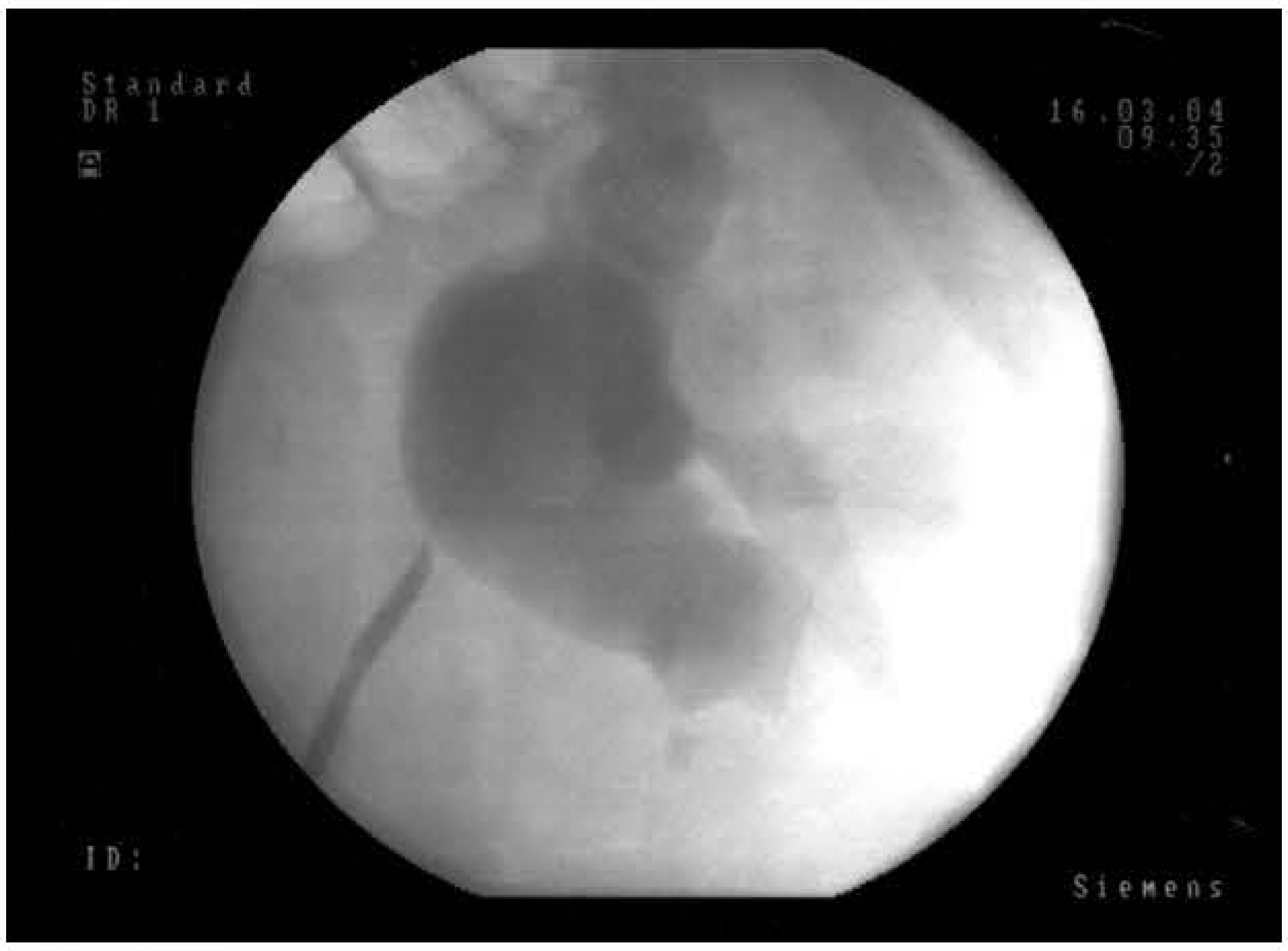


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FIGURE 5.6 **Primary UPJ stenosis.**

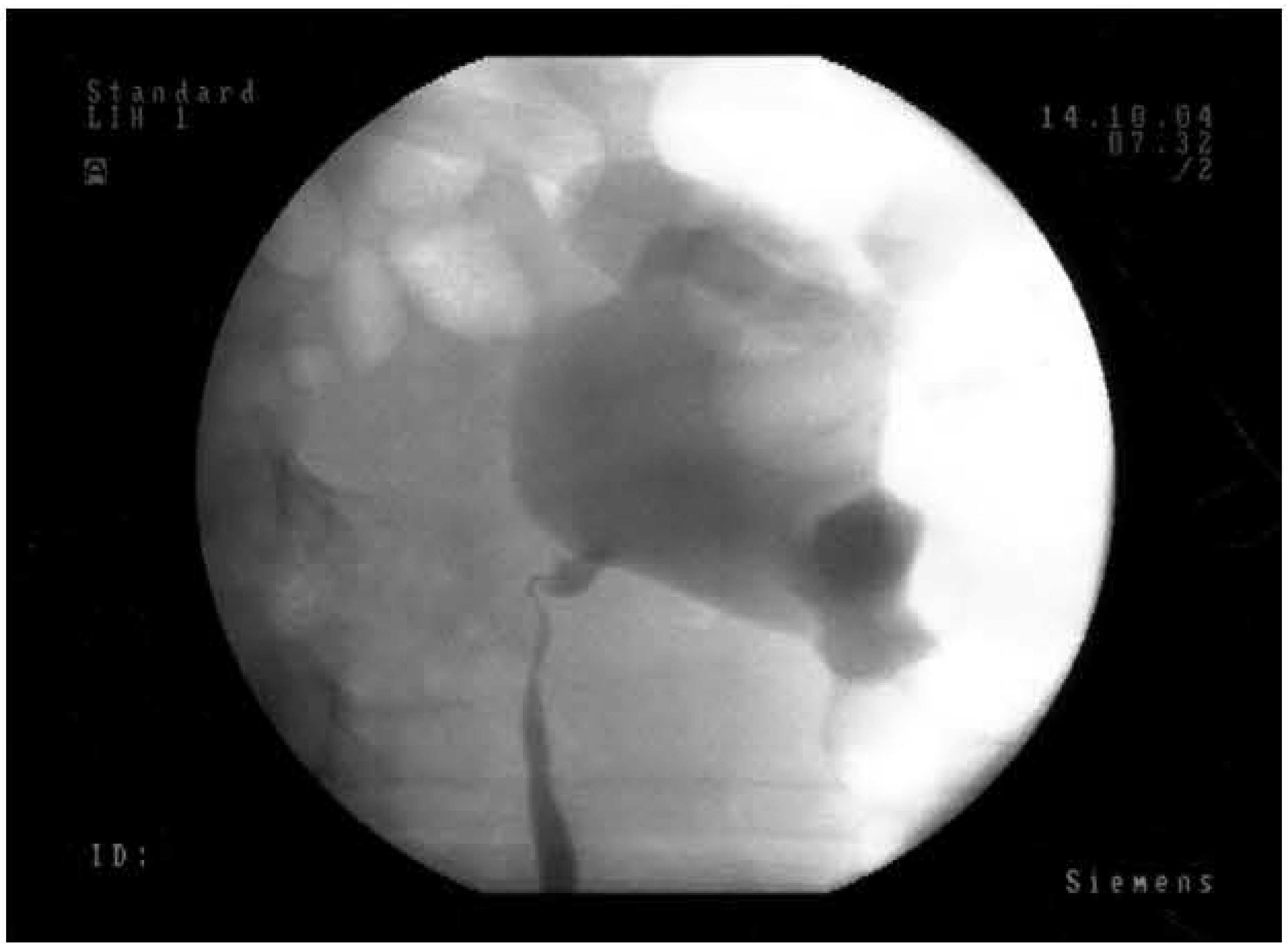

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FIGURE 5.7 **Secondary UPJ stenosis after pyeloplasty was performed 2 years before.**

5.2 INDICATIONS AND CONTRAINDICATIONS

The indications for treating UPJ stenosis are represented by:

- the presence of obstruction-related symptoms,
- global renal function impairment,
- progressive impairment of ipsilateral renal function,
- the presence of associated lithiasis,
- the presence of hypertension (rare).

In all these cases the treatment is intended to improve renal function. The type of surgical intervention is reconstructive and aims to create a normal nonobstructive urinary flow (Fallon et al., 2005).

Nevertheless, especially in neonates, choosing the optimal moment for surgery is a controversial topic (Koff, 1998; Hanna, 2000). Thus, some studies have shown that in a significant number of patients with congenital stenosis the obstruction is rather functional, without the progression of hydronephrosis and without renal function impairment (Koff, 1998; Poulakis et al., 2004). The reconstructive procedures are indicated regardless of age, when global or

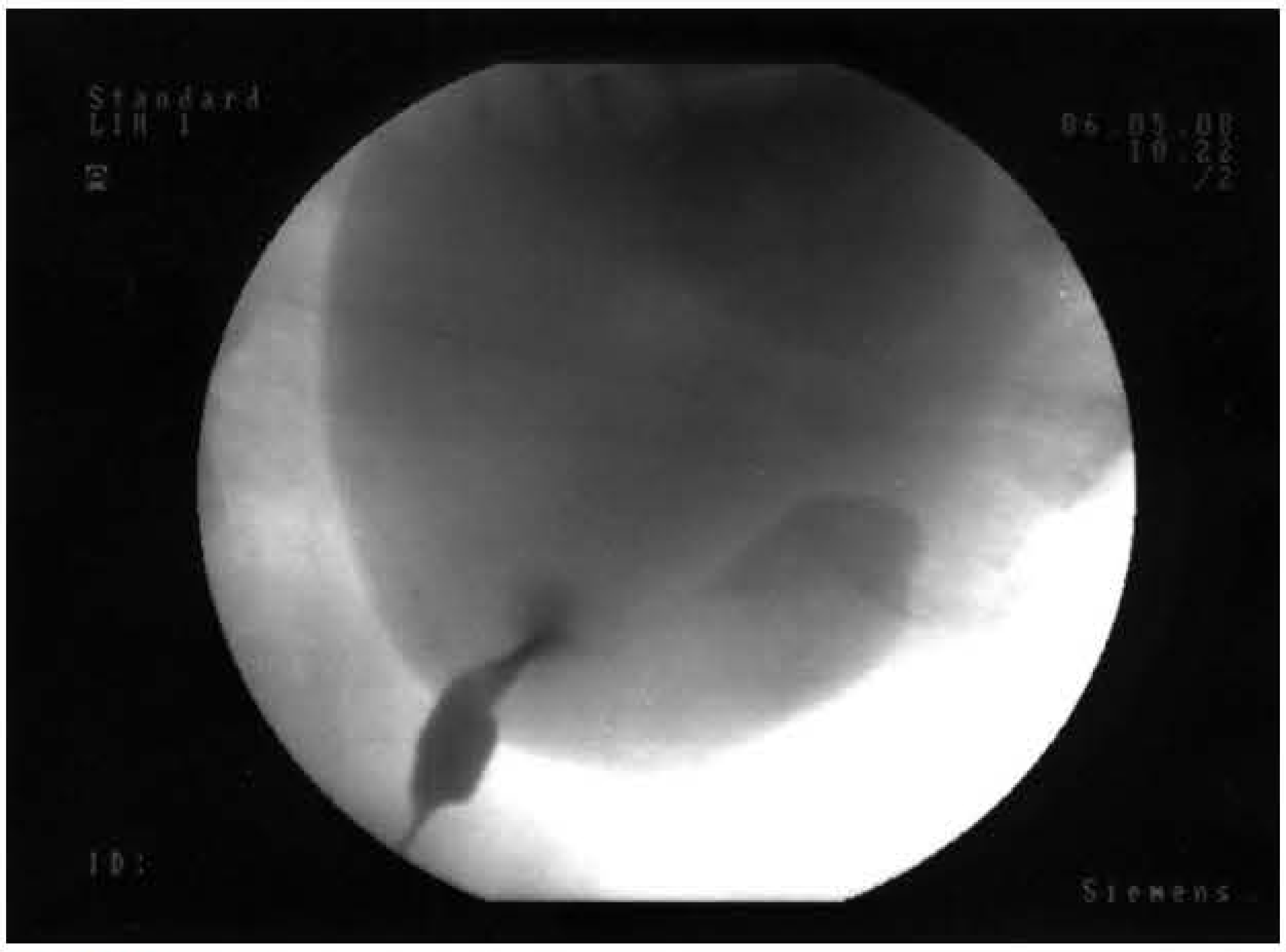

FIGURE 5.8 **UPJ stenosis with grade V hydronephrosis.**

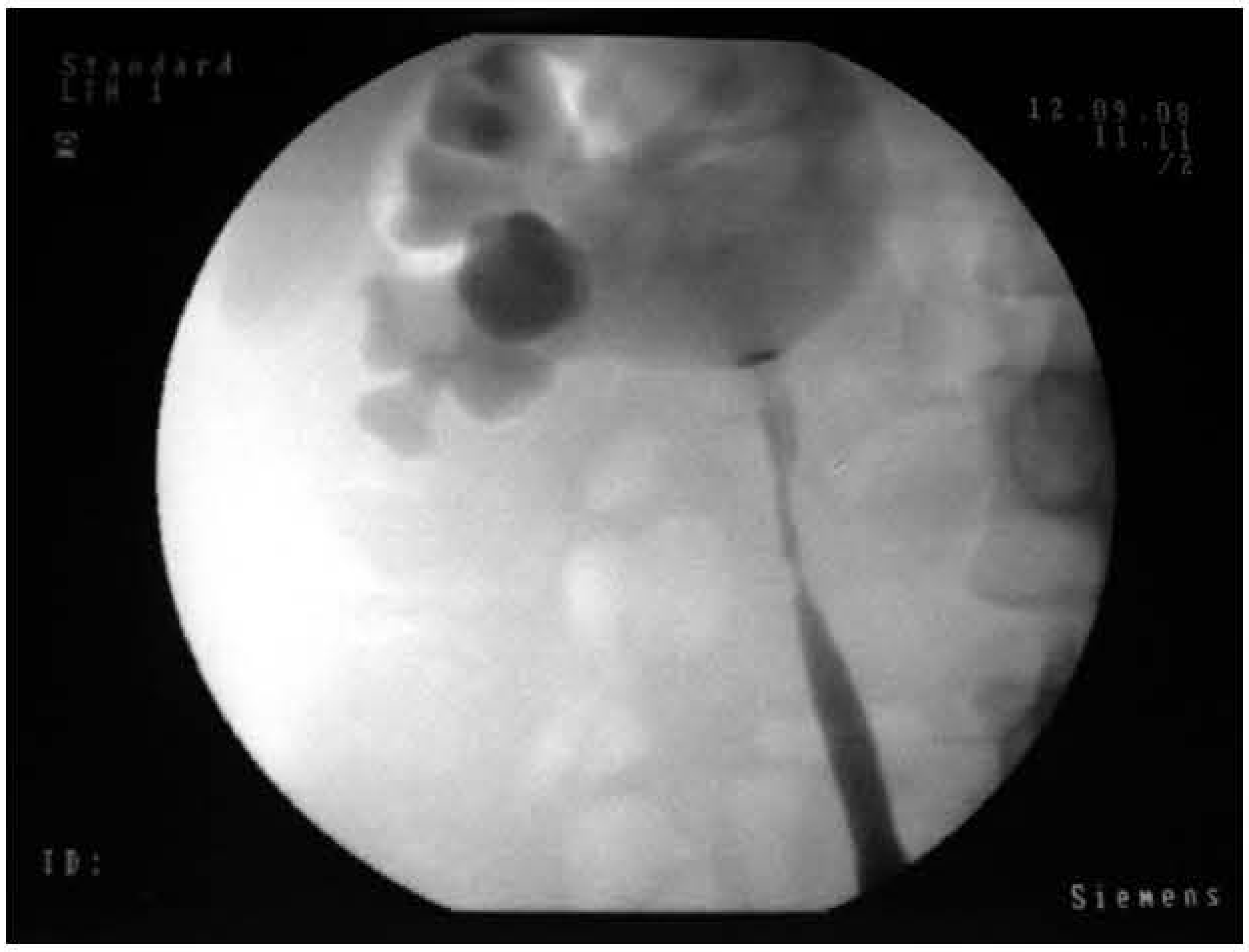

FIGURE 5.9 **UPJ stenosis associated with a subjunctional ureteral stenosis over a length greater than 2 cm, which contraindicates an endoscopic procedure.**

ipsilateral renal function impairment occurs, with very good results in most cases (Kumar et al., 1988; Rodrigues et al., 2002; Tallai et al., 2004).

The surgical intervention which is most frequently indicated is pyeloplasty. Minimally invasive procedures such as laparoscopic pyeloplasty are preferred lately due to the very good long-term results, comparable to those of open surgical interventions (Brannen et al., 1988; Gerber and Kim, 2000; Motola et al., 1993b).

Endopyelotomy represents one of the useful endoscopic procedures for treating UPJ stenosis. In various studies conducted so far, a success rate of approximately 73% has been reported (Talner, 1990). Currently, the indications for an endoscopic procedure versus an open one are under debate, personalized treatment taking into account especially the risk–benefit ratio of each patient. Each therapeutic alternative must be discussed with the patient. Although most patients prefer minimally invasive procedures, the assessment of the risk–benefit ratio is essential. In "secondary" UPJ stenoses, endopyelotomy is a viable alternative, with favorable results (Geavlete et al., 2001b; Geavlete et al., 2002; Jabbour et al., 1998).

The indication for percutaneous endopyelotomy was initially reserved for patients with associated lithiasis or relapse following pyeloplasty. The good results in these cases have determined the extension of the indication to also include primary UPJ stenoses. Presently, the antegrade approach is indicated especially in cases with associated lithiasis. Still, due to the dissemination of flexible ureteroscopy and progress regarding laser technology, many urologists lately prefer the retrograde endoscopic approach that allows for both UPJ incision and lithotripsy of kidney stones in the course of a single procedure.

In selected cases with nonfunctioning kidneys on urography and scintigraphy, the most common therapeutic alternative is represented by nephrectomy (Fig. 5.8).

In cases where ultrasound or CT show a greatly diminished renal parenchyma, initial drainage through a ureteral stent or percutaneous nephrostomy is indicated, to assess if the renal function can be rescued, followed by reassessment. Nephrectomy can be performed in patients with compromised renal function, and only in the presence of a normal contralateral kidney.

The contraindications for antegrade endopyelotomy are represented by:

- stenosis over a length greater than 2 cm (Fig. 5.9)
- urinary infection
- coagulopathy

The presence of polar vessels (Fig. 5.10) is a relative contraindication. Nevertheless, the presence of a polar vessel will usually determine the failure of any endourological approach. The presence of polar vessels can be suspected on the urographic examination and can be confirmed by color Doppler ultrasonography and by CT with tridimensional reconstruction. Angiography is not routinely indicated due to its invasiveness.

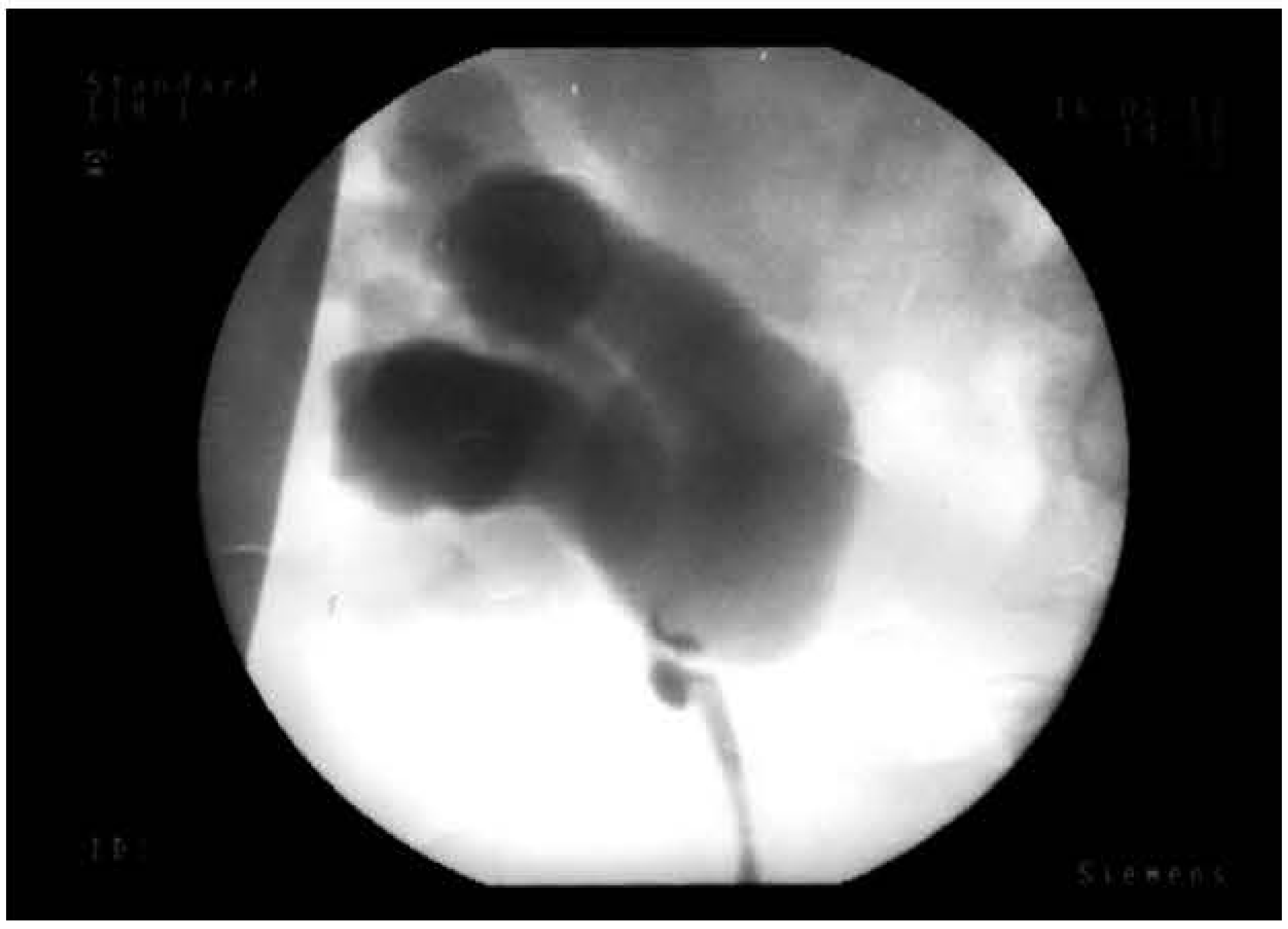

FIGURE 5.10 **UPJ stenosis due to a lower polar vessel.**

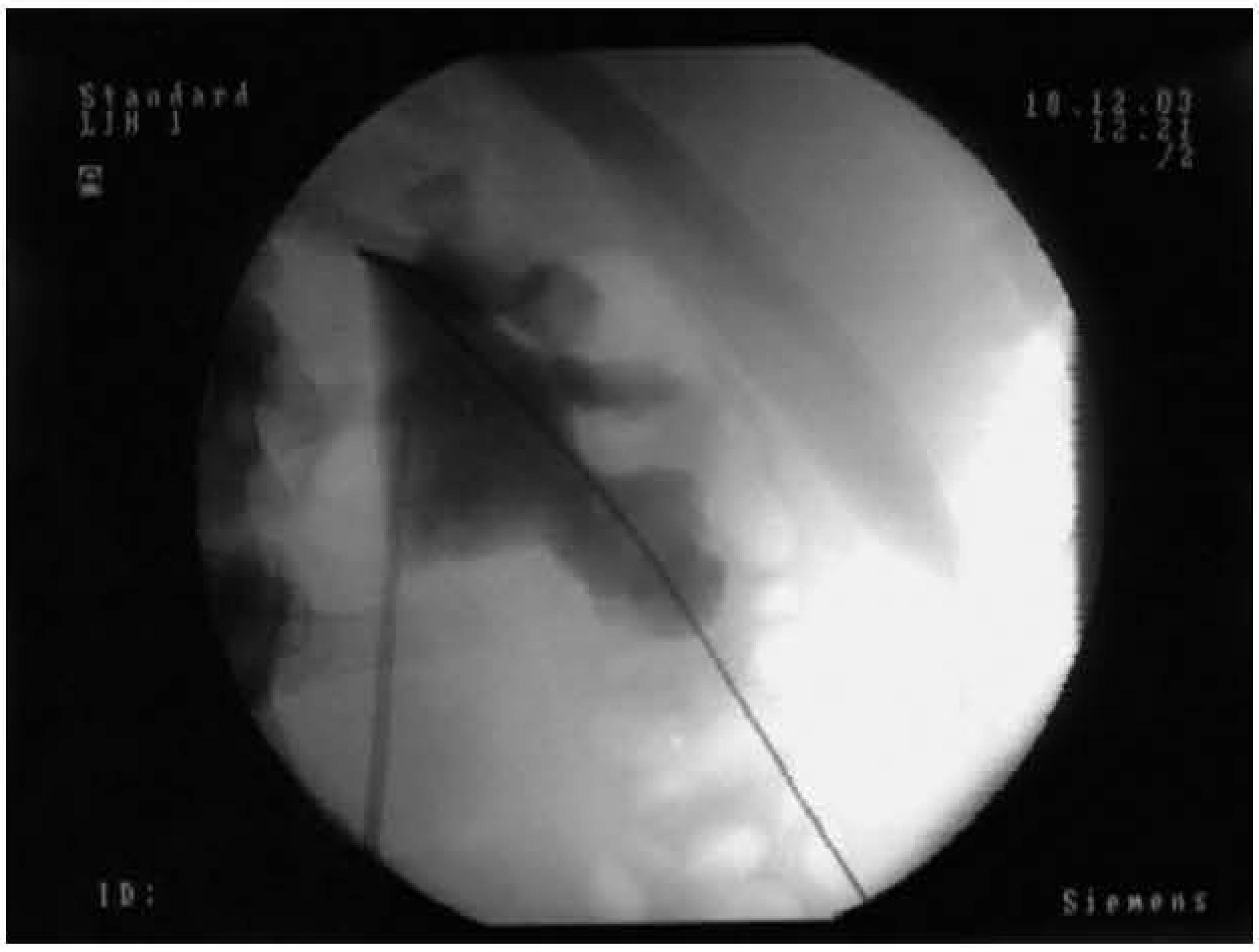

FIGURE 5.11 **Lower caliceal approach for antegrade endopyelotomy.**

5.3 TECHNICAL ELEMENTS OF ANTEGRADE ENDOPYELOTOMY

The endourological treatment of UPJ stenosis was first introduced by Ramsey in 1984 as "percutaneous pyelolysis." The technique was later performed in the United States by Badlani (1986) as endopyelotomy.

Although there are several technical variants, the principle of treatment consists of the incision of the proximal ureter until the peripyelic and periureteral fat is exposed. A stent is placed after the incision.

Endopyelotomy can be performed antegradely by percutaneous approach, or retrogradely by ureteroscopic approach. The retrograde technique, currently used more and more frequently, has a well-documented efficacy, equivalent to that of percutaneous procedures in selected cases. The endourological treatment of UPJ stenosis can be performed using: balloon dilation, junction incision with the Acucise catheter, and incision with cold knife, Collins loop, or laser fiber.

The preparation of patients for antegrade endopyelotomy is similar to that for the antegrade approach of kidney stones, with preoperative urine sterilization and objectification of other initial morbid conditions.

Antegrade endopyelotomy requires endoscopic access to the UPJ. To create a percutaneous tract, it is absolutely necessary to overcome the UPJ with a ureteral catheter used for injecting the contrast medium to opacify the pyelocaliceal system.

Transpapillary caliceal puncture can be performed under fluoroscopic or ultrasonographic guidance. Puncture under fluoroscopic control requires the opacification of the pyelocaliceal system. The calyx, regardless of which group it belongs to (lower, middle, or upper), must have a posterior spatial disposition. The puncture must be made strictly transpapillary on the avascular line to avoid the risk of bleeding when performing the percutaneous tract's dilation. Along with the contrast agent, a colored substance can also be injected through the ureteral catheter (diluted methylene blue), which certifies the puncture into the pyelocaliceal system. In certain cases, the use of double contrast by injecting air can differentiate the posterior calyces from the ones located anteriorly.

The puncture is preferably performed in the middle or upper calyx, which provides a better exposure of the junction, thus facilitating the incision. In selected cases, access through the lower calyx can also be used (Fig. 5.11).

The puncture can also be guided by ultrasonography. Although the ultrasound machine allows for a very accurate orientation regarding the spatial distribution of the calyces, a strictly transpapillary approach is more difficult to achieve. In the case of an ultrasonographically guided puncture, it is useful to inject a mixture of saline solution and methylene blue through the ureteral catheter. The intervention can then be conducted under ultrasonographic (more difficult) or fluoroscopic control (most frequent).

After the puncture, a guidewire is placed through the puncture needle's channel. The guidewire should penetrate the pyelocaliceal system, its position being fluoroscopically monitored.

The dilation of the percutaneous tract is similar to the one for lithiasic pathology. After the dilation, the Amplatz sheath is placed (28 or 30 Ch depending on the instruments to be used to perform endopyelotomy), which is necessary to easily manipulate the instruments and any lithiasic fragments (Fig. 5.12).

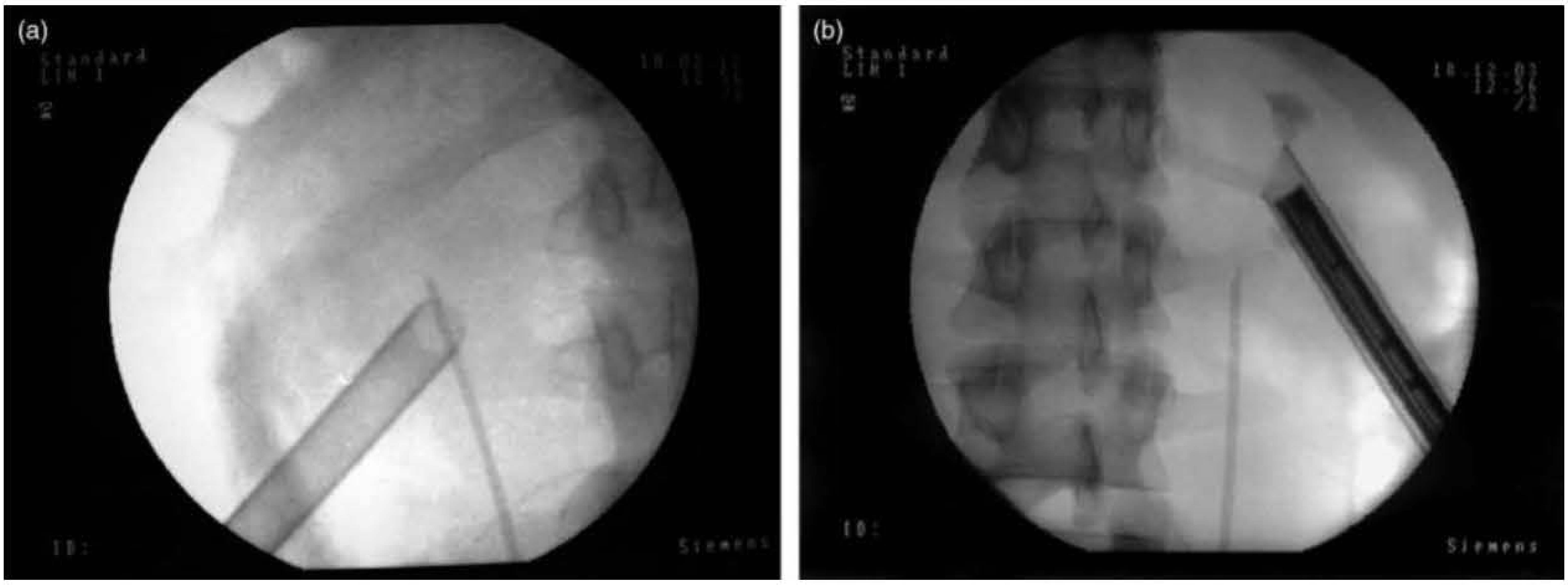

FIGURE 5.12 **Placing the Amplatz sheath in patients with UPJ stenosis and associated lithiasis.** (a) Radiotransparent lithiasis and (b) radiopaque lithiasis (fluoroscopic aspects).

In the case of cold knife or Collins loop incision, the percutaneous tract should allow for a direct approach of the junction, because rigid instruments are used in these cases.

Laser incision allows the use of flexible instruments (flexible nephroscope), which has great advantages on the working method.

After creating the nephrostomy tract visualizing the junction, it is useful to place a second safety guidewire, so that two guidewires that cross the junction can be identified fluoroscopically.

The original technique described by Ramsay and taken over by Badlani consists of performing endopyelotomy with the knife “out front.” The endopyelotome used had the shape of a hook that incised the junction in its entire thickness, from the ureteral lumen toward the peripyelic and periureteral fat. The incision should be extended several millimeters toward the normal ureter.

According to some authors the incision should be made laterally (Sampaio, 1998), thus avoiding damage to the polar vessels. The incision should be made in the area where there is a sudden narrowing of the lumen. Particular attention must be paid to any pulsation of a potential vessel located in the vicinity of the incision area. If pulsations are noticed, the incision must avoid these areas. Also, under direct visual control, any blood vessels can also be observed and therefore can be avoided.

Changing the original technique consists of the use of the Collins loop for incision (Fig. 5.13) and of prior stenting of the junction (Savage and Streem, 2000).

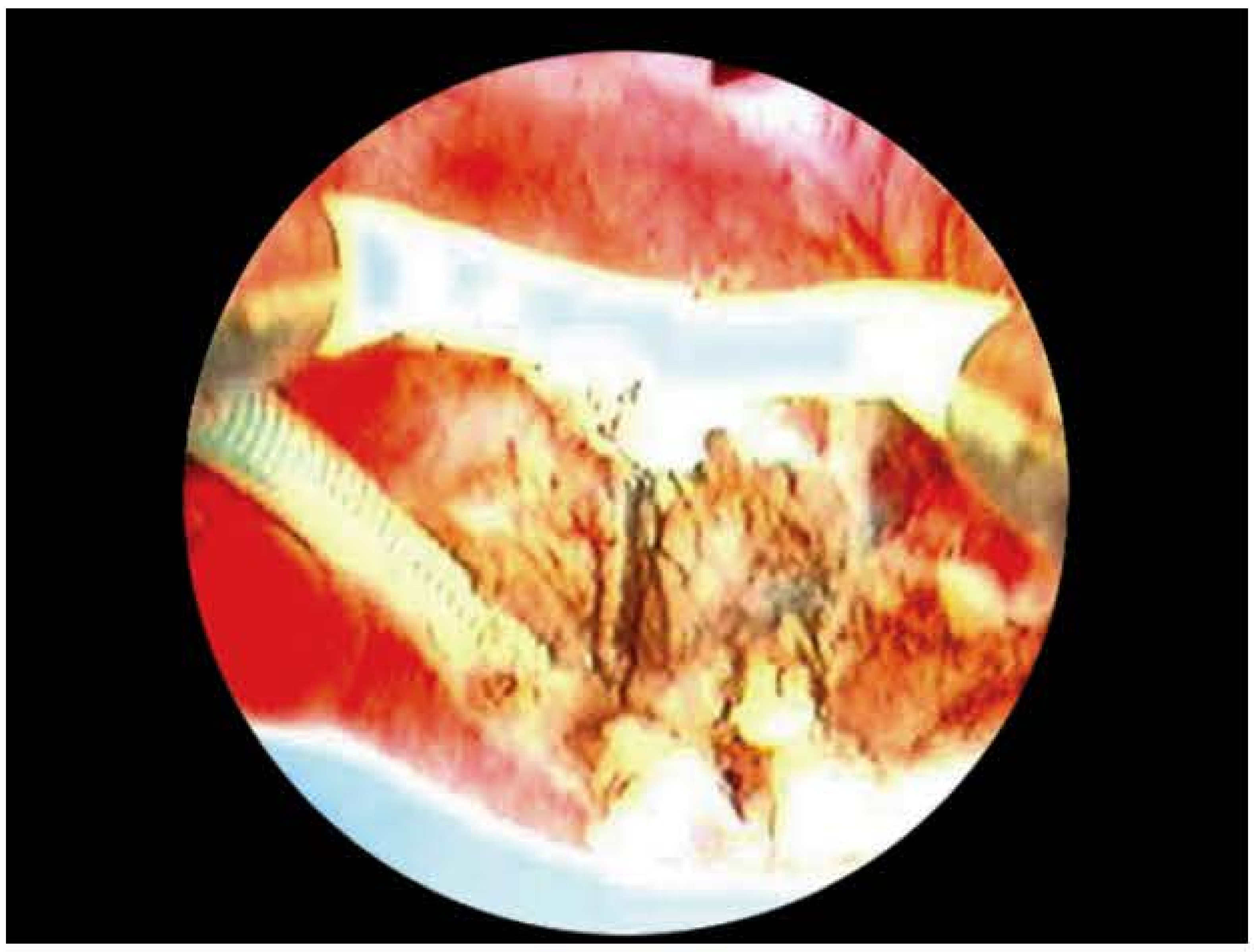

FIGURE 5.13 **Incision of a UPJ stenosis using the Collins loop.**

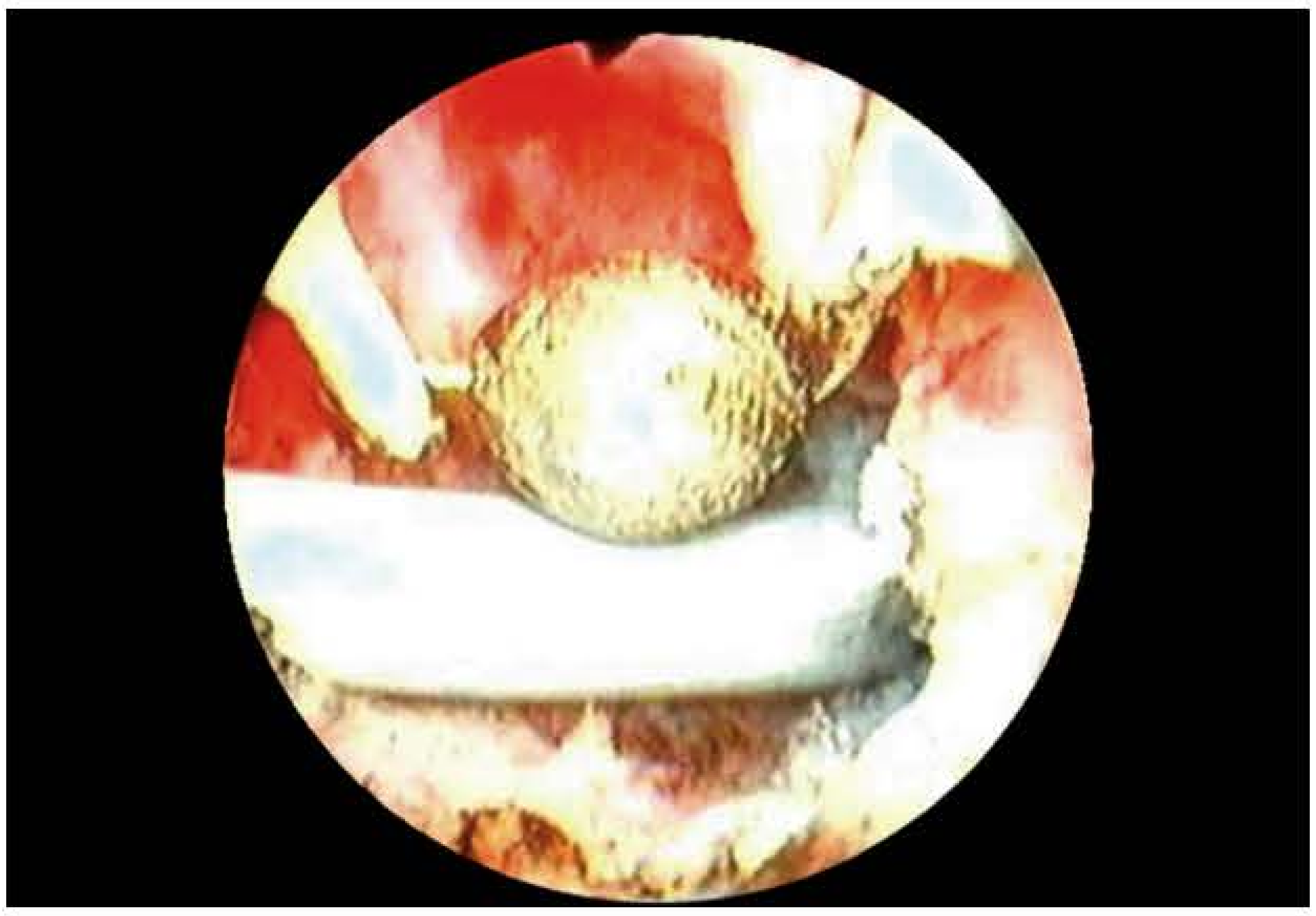

FIGURE 5.14 **The coagulation of vessels accidentally damaged during antegrade endopyelotomy.**

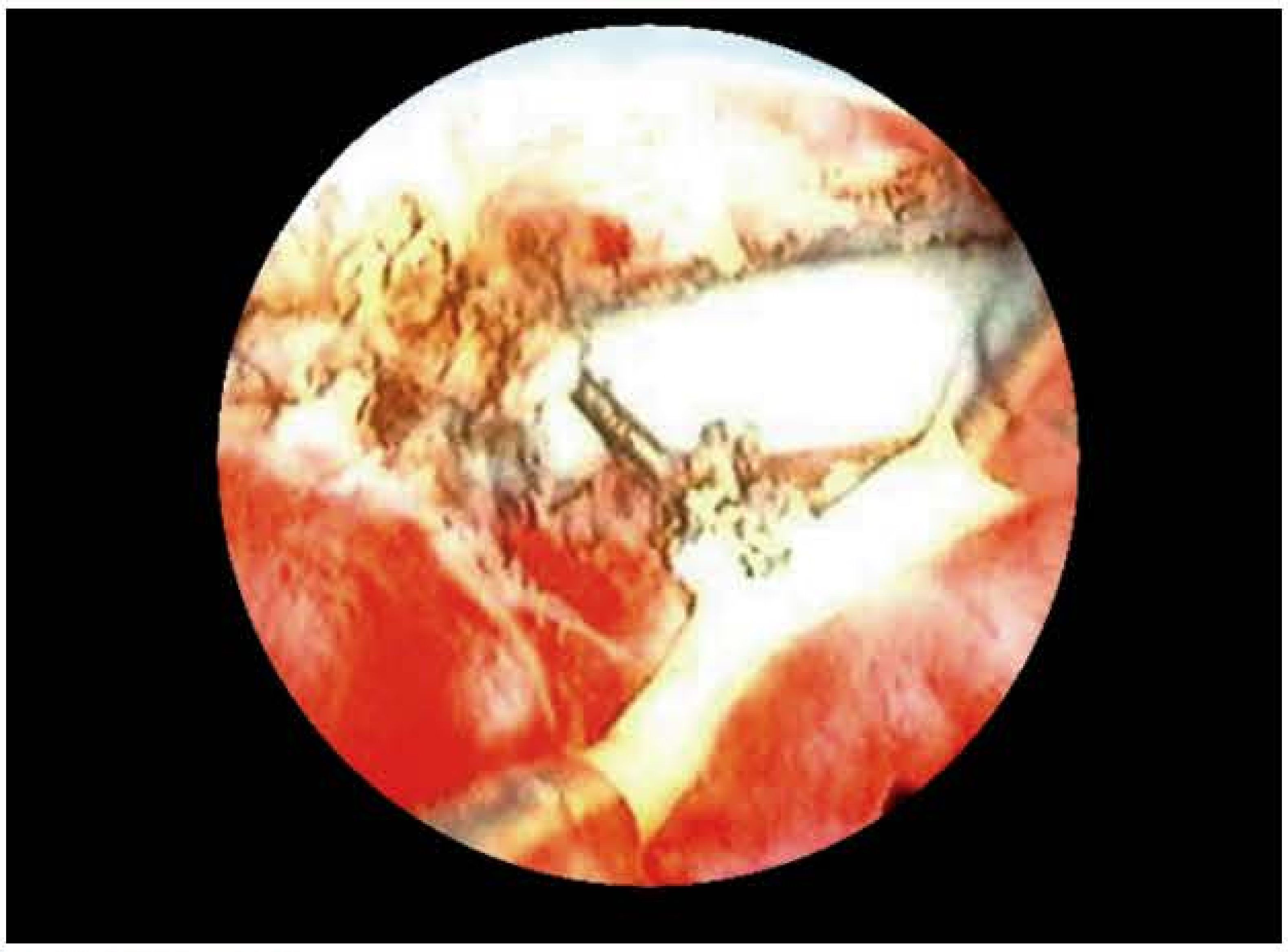

FIGURE 5.15 **Antegrade incision of a UPJ stenosis using the Collins loop.** The junction is intubated with a plastic ureteral catheter to isolate the ureter from the undesired effect of high-frequency current.

The disadvantage of using the Collins loop is represented by the local diathermal effect, which is, however, of a low intensity and without negative consequences. On the other hand, hemostasis of small, accidentally injured vessels can be achieved (Fig. 5.14).

Preoperative ureteral stent placement has two advantages: it allows the individualization of the junction with the possibility of making more accurate incisions and decreases the risk of UPJ avulsion when the pyelostent is placed (after making the incision).

The ureteral catheter is placed at the beginning of the intervention and used as a tutore, the incision is made using a "bugbee"-type electrode or the Collins loop. The ureteral catheter allows the use of a higher intensity (cutting) current, isolating the rest of the ureter from the incised area (Figs 5.15 and 5.16).

In recent years the incision has been made using energy generated by laser: neodymium:YAG (Fig. 5.17), holmium:YAG (Fig. 5.18), diode, etc. These emit coherent light which is transmitted punctiformly through fibers with dimensions of 365 or 200 μm, having a great precision for making the incision. In addition, tissue penetrability is low, and by using the appropriate program the laser enables the coagulation of small vessels, so that the operation is carried out completely without bleeding, the surgical field is permanently clear, and in time the developed scar is more subtle. Even so, the success rate using the laser is not much higher than for the other types of incision (Cinman, 2010).

For the incision to be efficient, it must exceed the ureteral wall at the site of stenosis. This is accomplished by viewing the periureteral and peripyelic fat during the intervention and is radiologically certified by the leakage of contrast medium at the level of the incision (Fig. 5.19).

When lithiasis is associated with UPJ stenosis, pyelolithotomy should be the first step of the intervention to avoid fragment migration through the breach created by the incision (Fig. 5.20). Lithiasic fragments that could migrate through this breach can cause fibrosis or fibrous granuloma and can compromise the outcome of the intervention (Giddens and Grasso, 2000).

After the incision is made, an 8/12 Ch stent is placed antegradely. If the passage of the stent is impossible due to its thickness, a 6/10 Ch pyelostent can be placed, or even a standard 8 Ch stent. Placing the pyelostent is performed under fluoroscopic control (Fig. 5.21). Generally, the stent is held in place for 4–6 weeks.

The nephrostomy tube is maintained for 24–48 h, during which time it is indicated to perform the radiological control of the correct positioning of the pyelostent (Fig. 5.22).

5.4 RESULTS

Treatment alternatives that do not involve incision of the UPJ under visual control (balloon dilation, Acucise-type catheter) are not very popular today, particularly because of their poorer long-term outcomes.

Endoscopic treatment cannot achieve the reduction of the renal pelvis. Thus, a large renal pelvis due to a UPJ stenosis would remain a high-volume renal pelvis, even if the stenosis itself is resolved endoscopically. In these

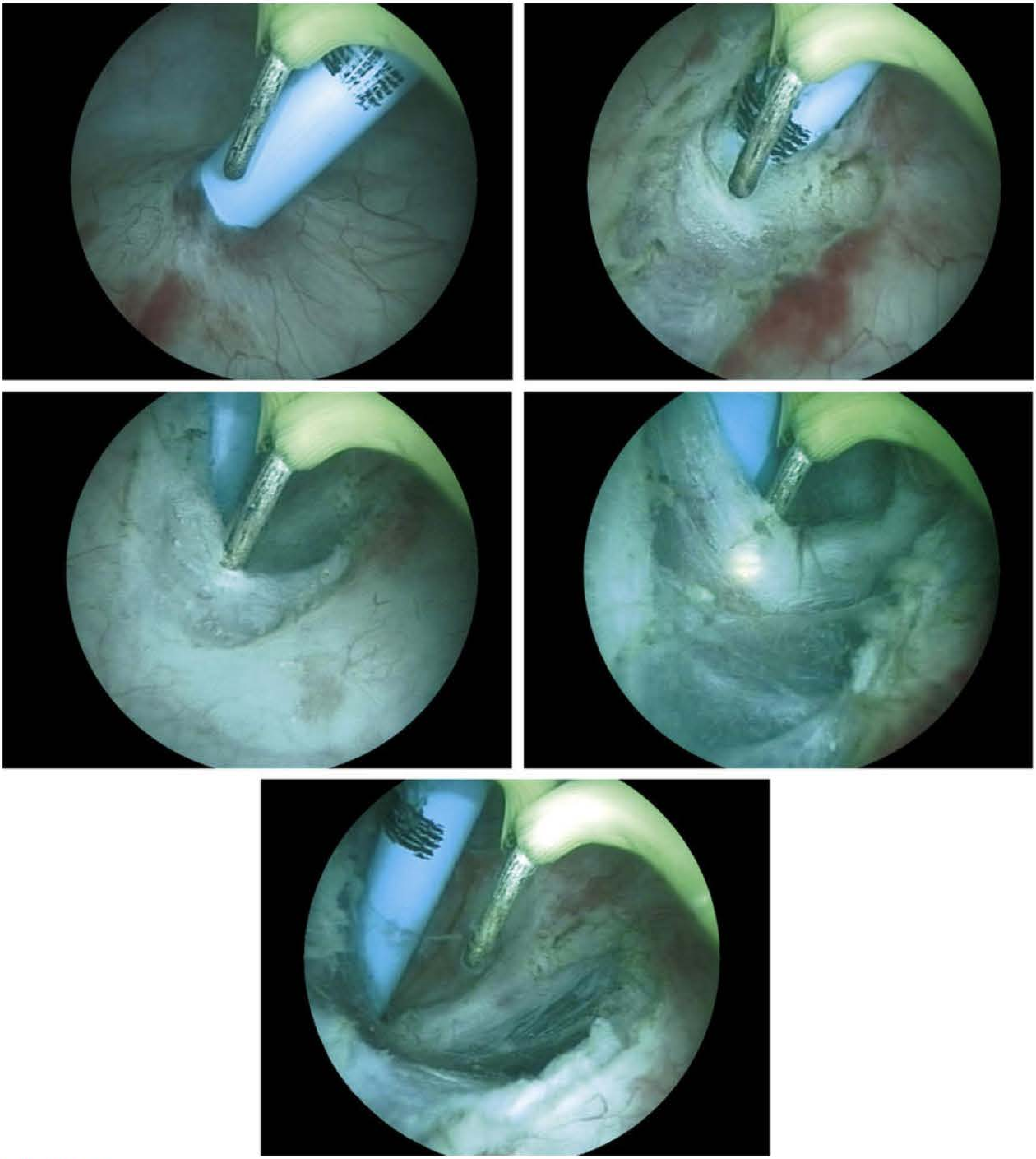

FIGURE 5.16 **Collins loop incision for UPJ stenosis.** The ureteral catheter is placed retrogradely as the first step of the intervention. UPJ incision is performed until the peripyelic and periureteral fat is clearly exposed.

circumstances, urography will show a large renal pelvis, but specific tests such as forced diuresis urography or renal scintigraphy will objectify the absence of obstruction.

A standardized protocol for assessing the postoperative results has not yet been established.

Proper selection of patients (excluding those with polar vessels and significant hydronephrosis) has determined the increase of the success rate for endopyelotomy up to 95% (result comparable to surgical pyeloplasty) (Danuser et al., 1998; Gerber and Lyon, 1994).

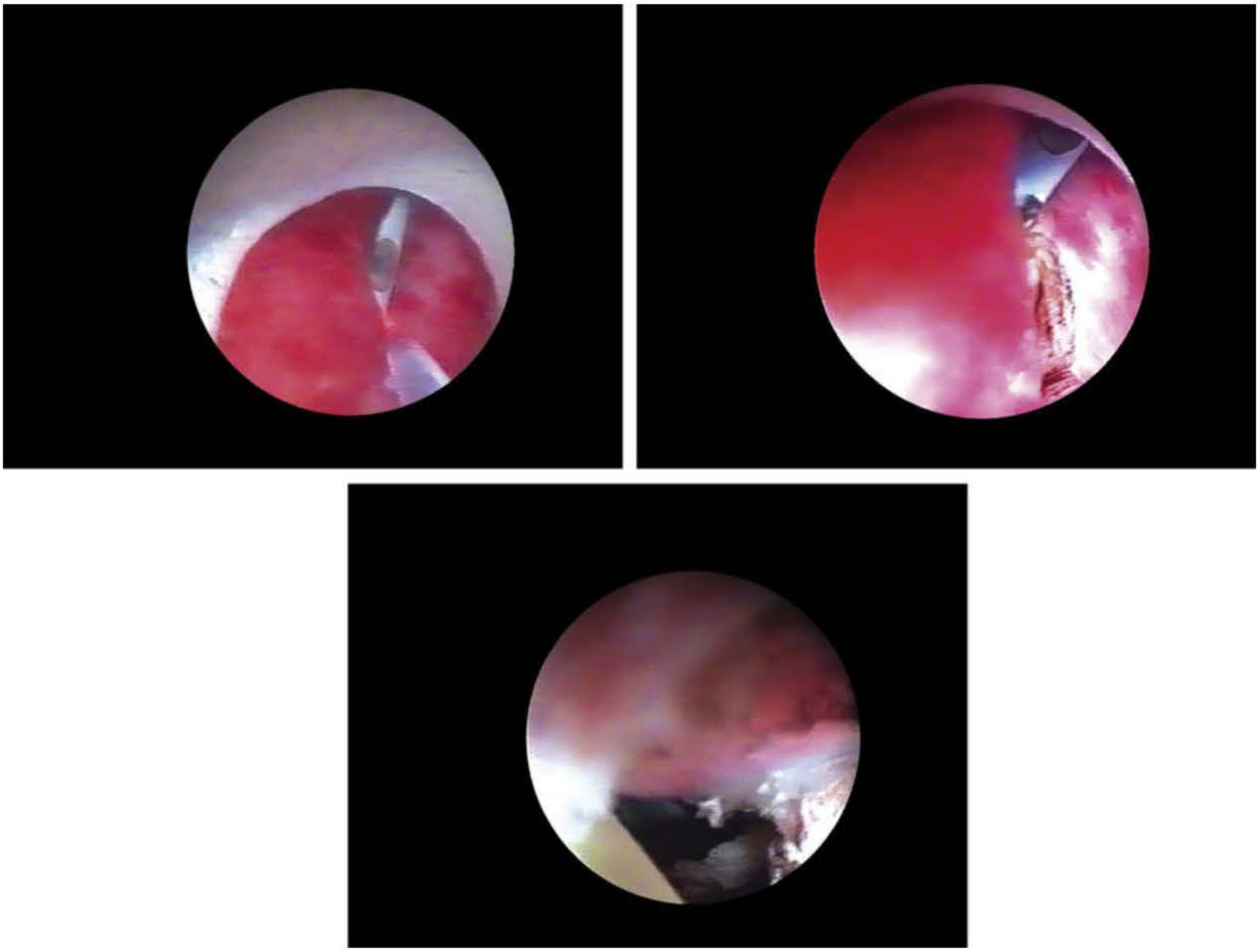

FIGURE 5.17 **Antegrade endopyelotomy using Nd:YAG laser fiber.** The incision is performed until the periureteral and peripyelic fat is exposed.

The first postoperative evaluation is done after 1 month from the extraction of the ureteral stent (when ureteral motility returns to normal).

Evaluation of the results can be done by: ultrasound, standard and forced diuresis urography, renal scintigraphy with isotopic nephrogram, contrast-enhanced CT.

Ultrasound may reveal the presence or absence of hydronephrosis, which in some cases may be residual, without clinical significance. In these situations Doppler ultrasound can be valuable, allowing the measurement of the resistive index (RI) in the interlobular arteries. This has a normal value of less than 0.7 (Fig. 5.23). Values above 0.7 indicate an obstructive syndrome. However, it is known that in very old UPJ stenoses the RI value may be normal, which limits the value of the method, other supplementary assessment methods being indicated.

Standard urography is indicated 1 month after extracting the ureteral stent, when ureteral motility is normal (Figs 5.24 and 5.25). Urography with forced diuresis allows highlighting the cases where standard examination is normal but the obstruction persists and becomes clinically apparent only in the case of increased diuresis.

Renal scintigraphy with isotopic nephrogram represents the exploration which best reflects kidney function. Although it is relatively rarely indicated in the follow-up of UPJ stenosis patients, it is particularly useful in cases with impaired renal function before surgery or in the case of bilateral UPJ stenoses operated sequentially (Fig. 5.26).

CT is not commonly used in the follow-up protocol of patients with UPJ stenosis, but is constantly used in cases of relapses for highlighting the possible causes of failure and for orienting the treatment.

In terms of postoperative pain, percutaneous endopyelotomy is well tolerated by patients. Nevertheless, on large series of patients, the overall success rate is approximately 73% over a follow-up period of 2–97 months. Recent results vary between 85% and 90%, probably due to the more judicious selection of patients and the accuracy of the method of treatment (Motola et al., 1993a; Shalhav et al., 1998a,b; Ost et al., 2005).

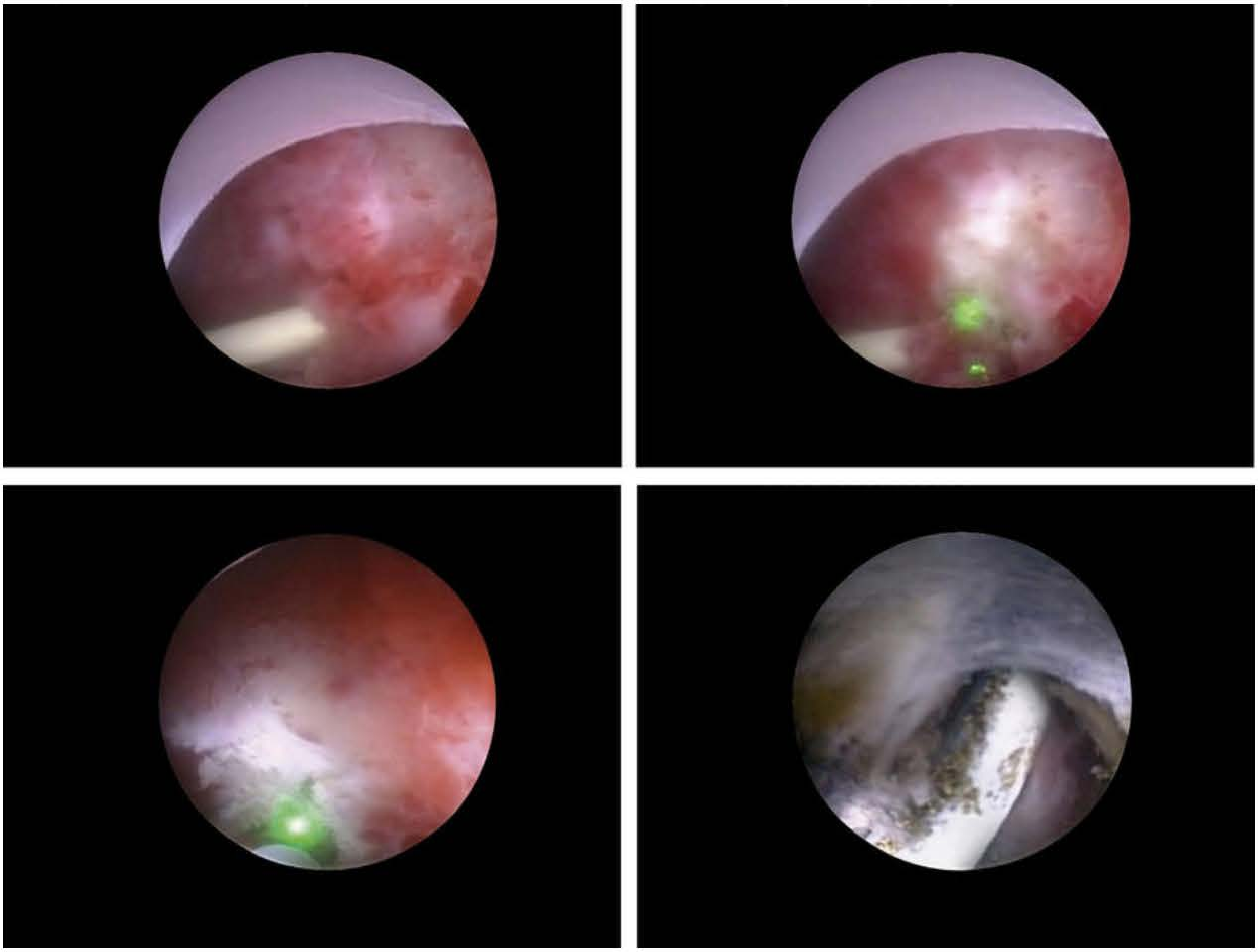

FIGURE 5.18 Antegrade endopyelotomy using Ho:YAG laser.

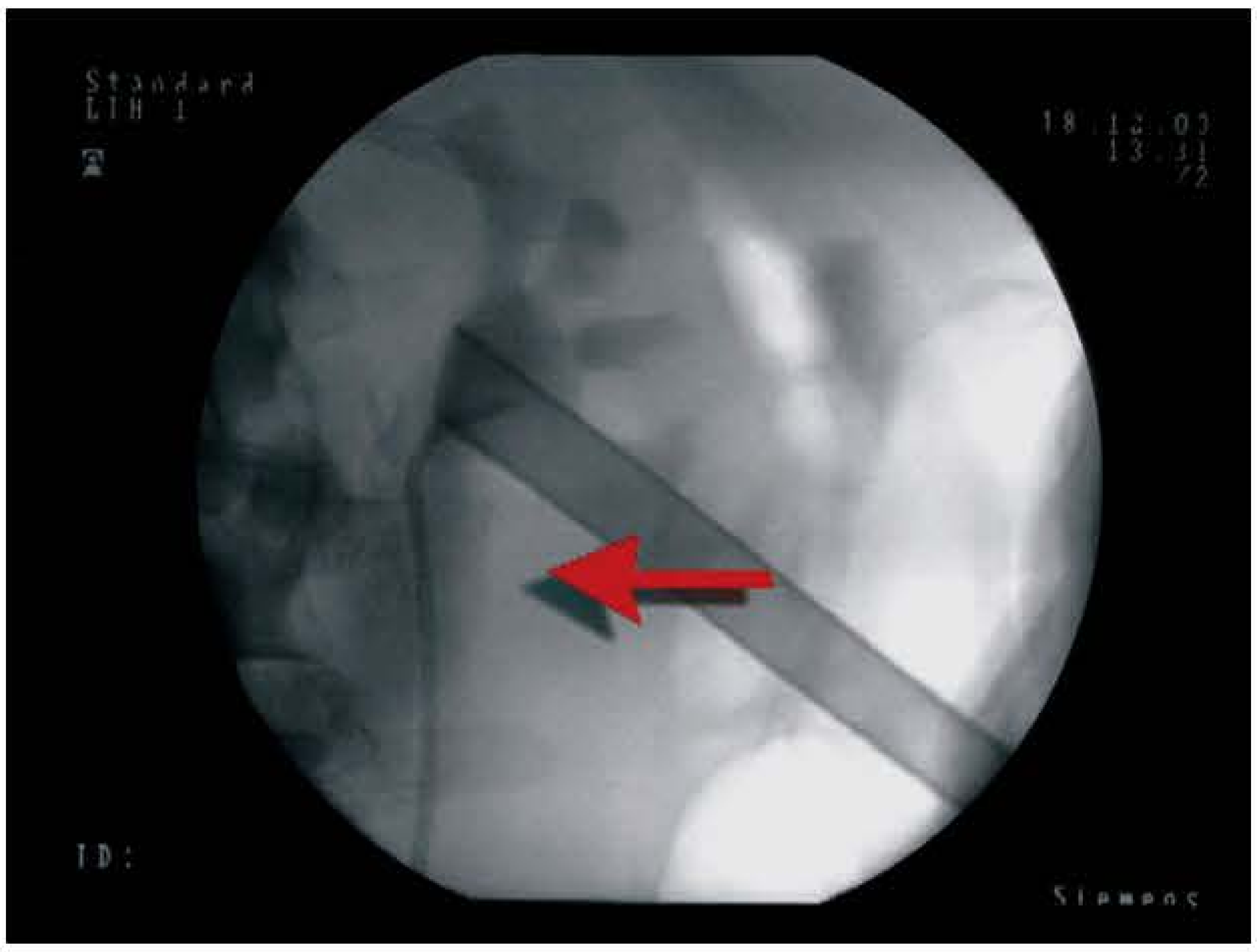
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FIGURE 5.19 Leakage of the contrast agent at the end of the antegrade endopyelotomy.

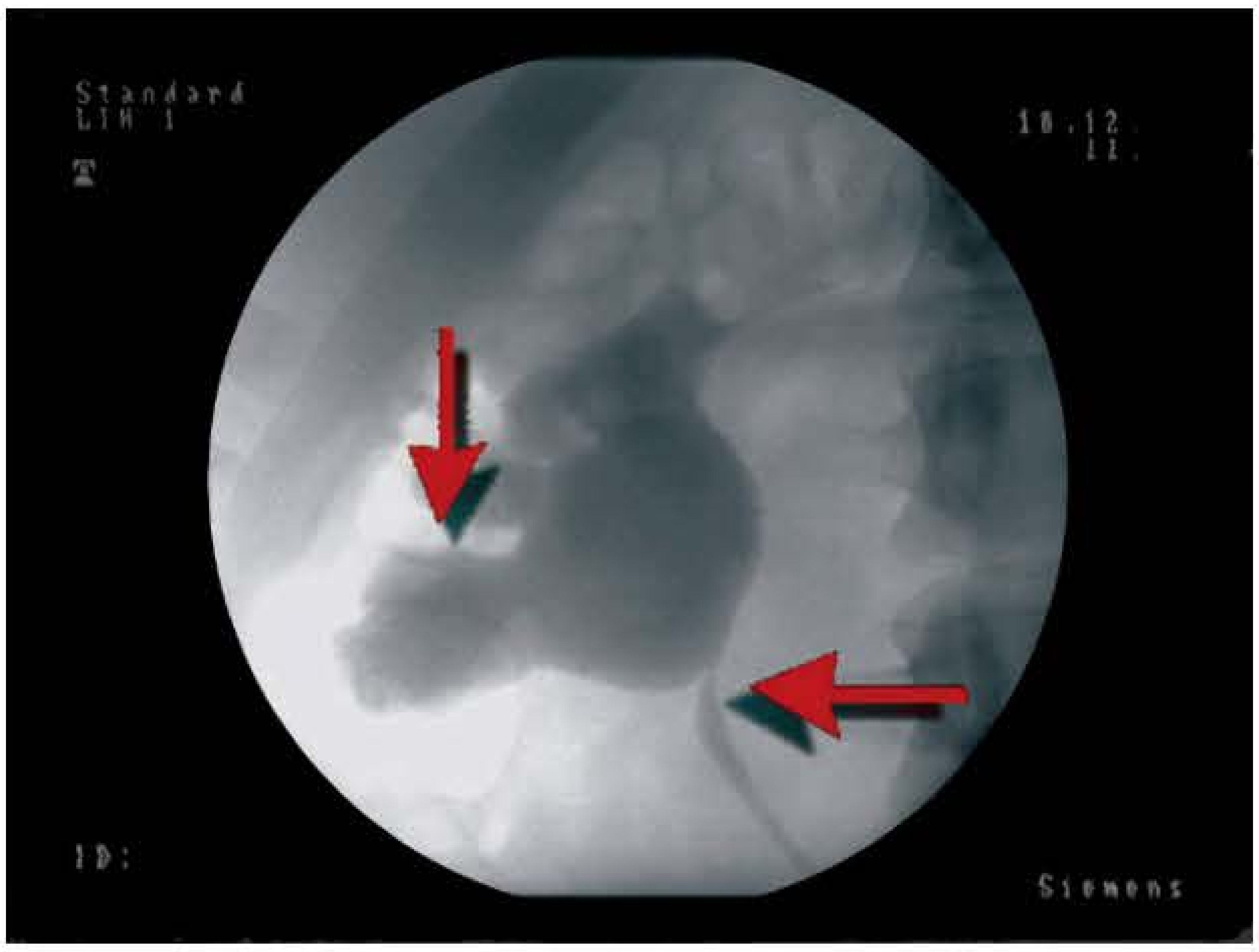
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FIGURE 5.20 UPJ stenosis associated with lower caliceal lithiasis.

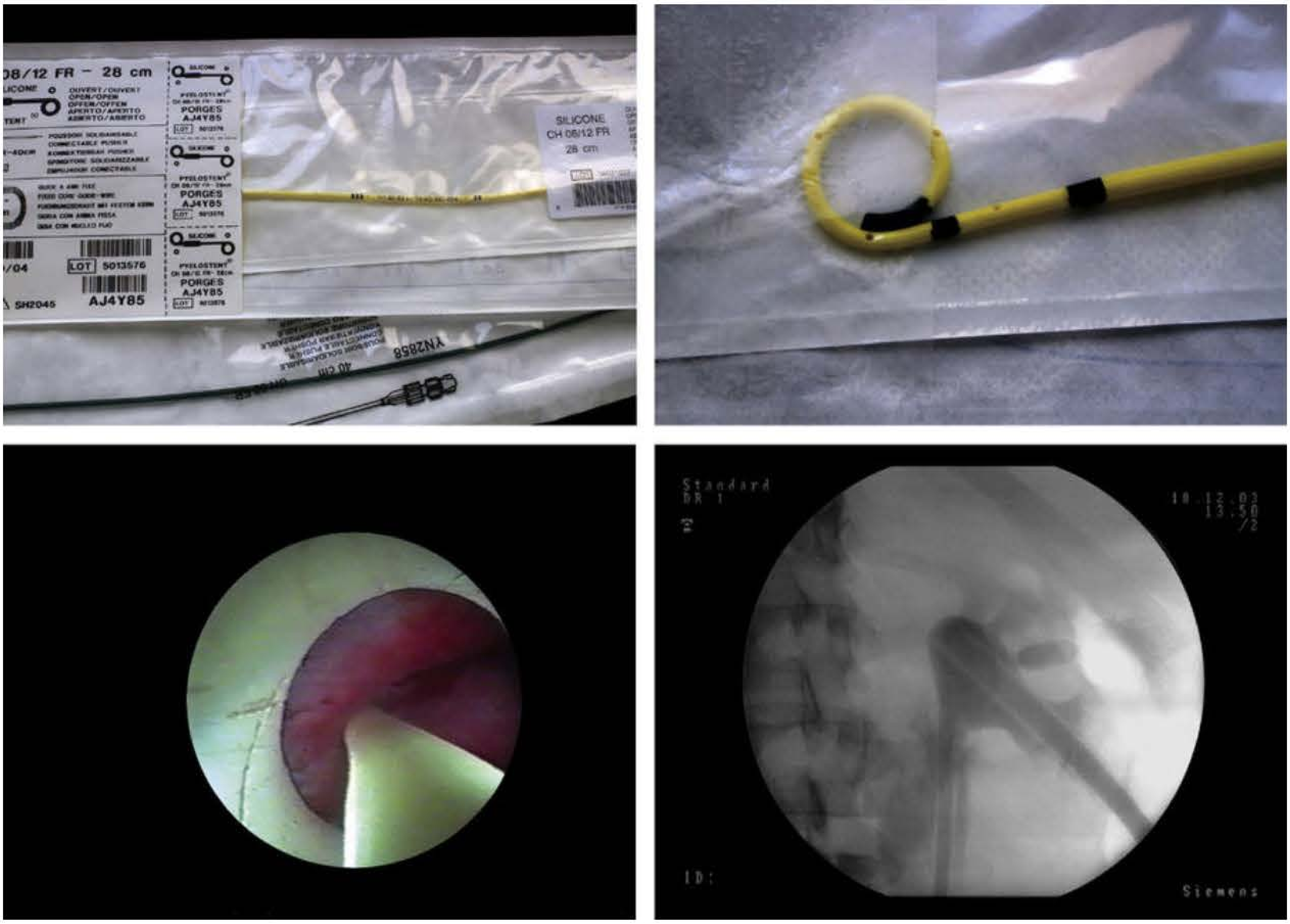
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FIGURE 5.21 **Porges-type stent (8/12 Ch) placed antegradely under fluoroscopic control.**

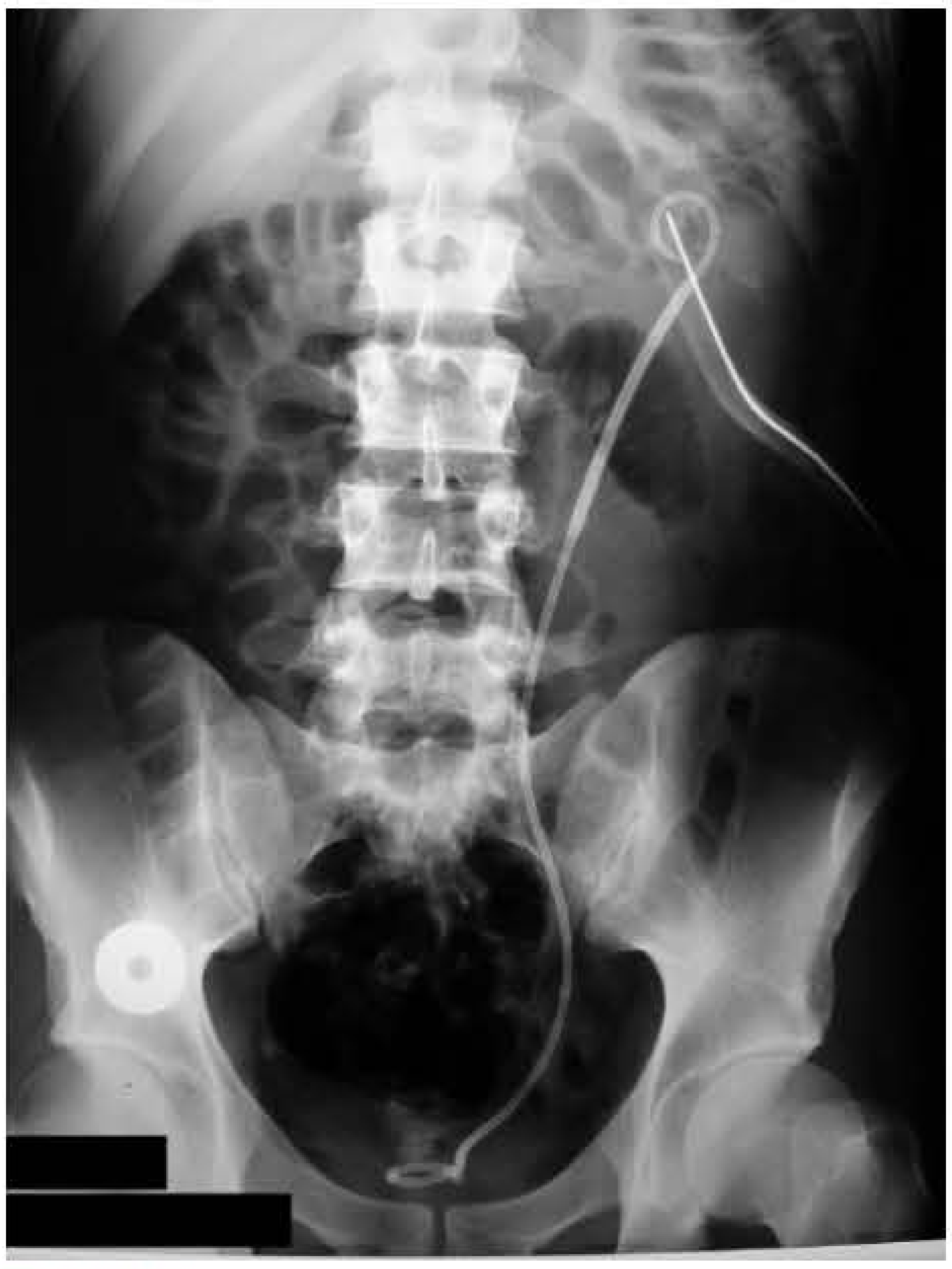
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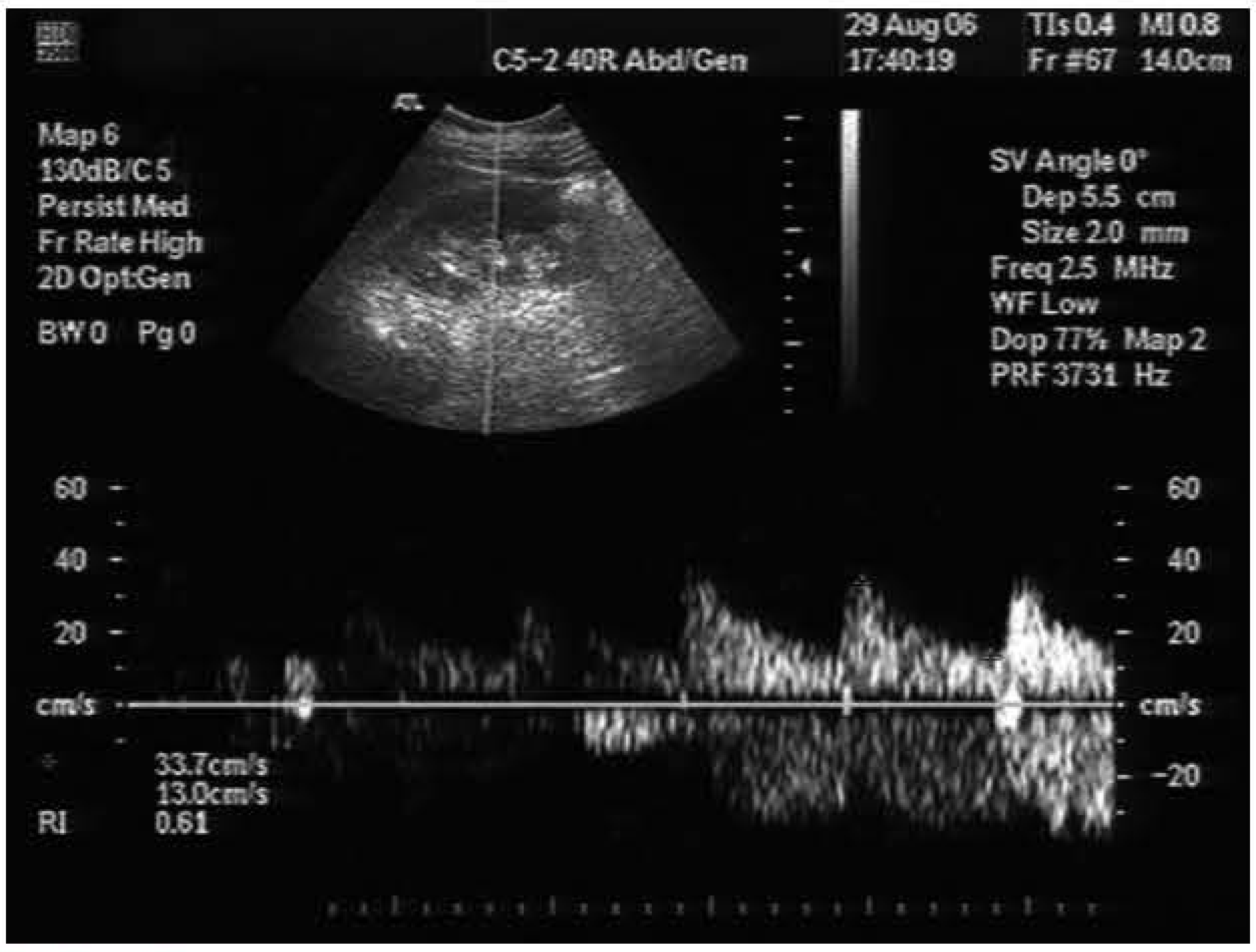
FIGURE 5.22 **Properly positioned pyelostent and nephrostomy tube on the second postoperative day after antegrade endopyelotomy.**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WF Low
Dop 77% Map 2
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60
40
20
cm/s
-20
33.7cm/s
13.0cm/s
RI 0.61

FIGURE 5.23 **Color Doppler ultrasound, 2 years after endopyelotomy.** Normal ecographic renal appearance with grade I residual hydronephrosis and a resistive index of 0.61.

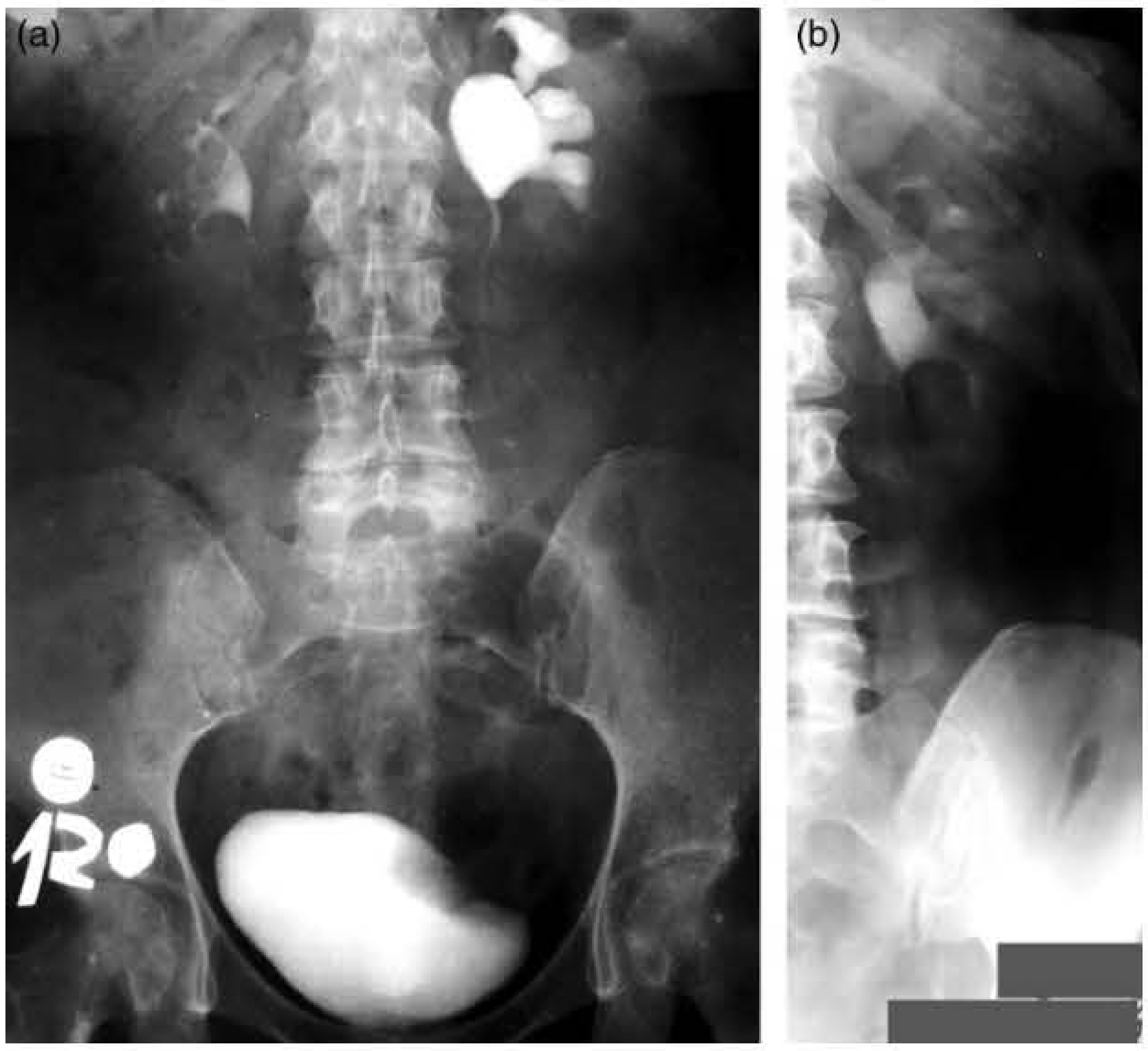


FIGURE 5.24 **Pre- (a) and postoperative (b) urography at 1 month after retrograde endopyelotomy.**

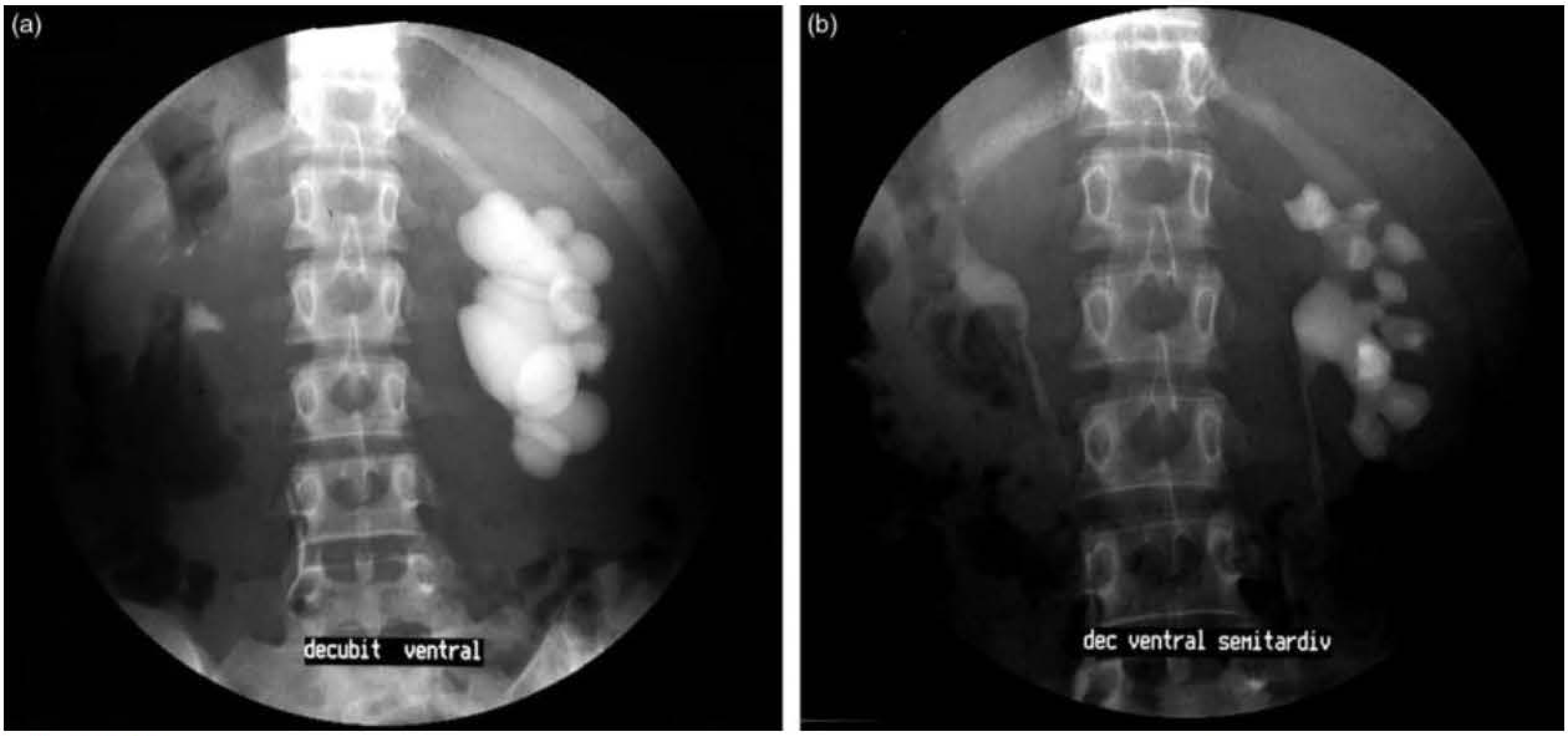
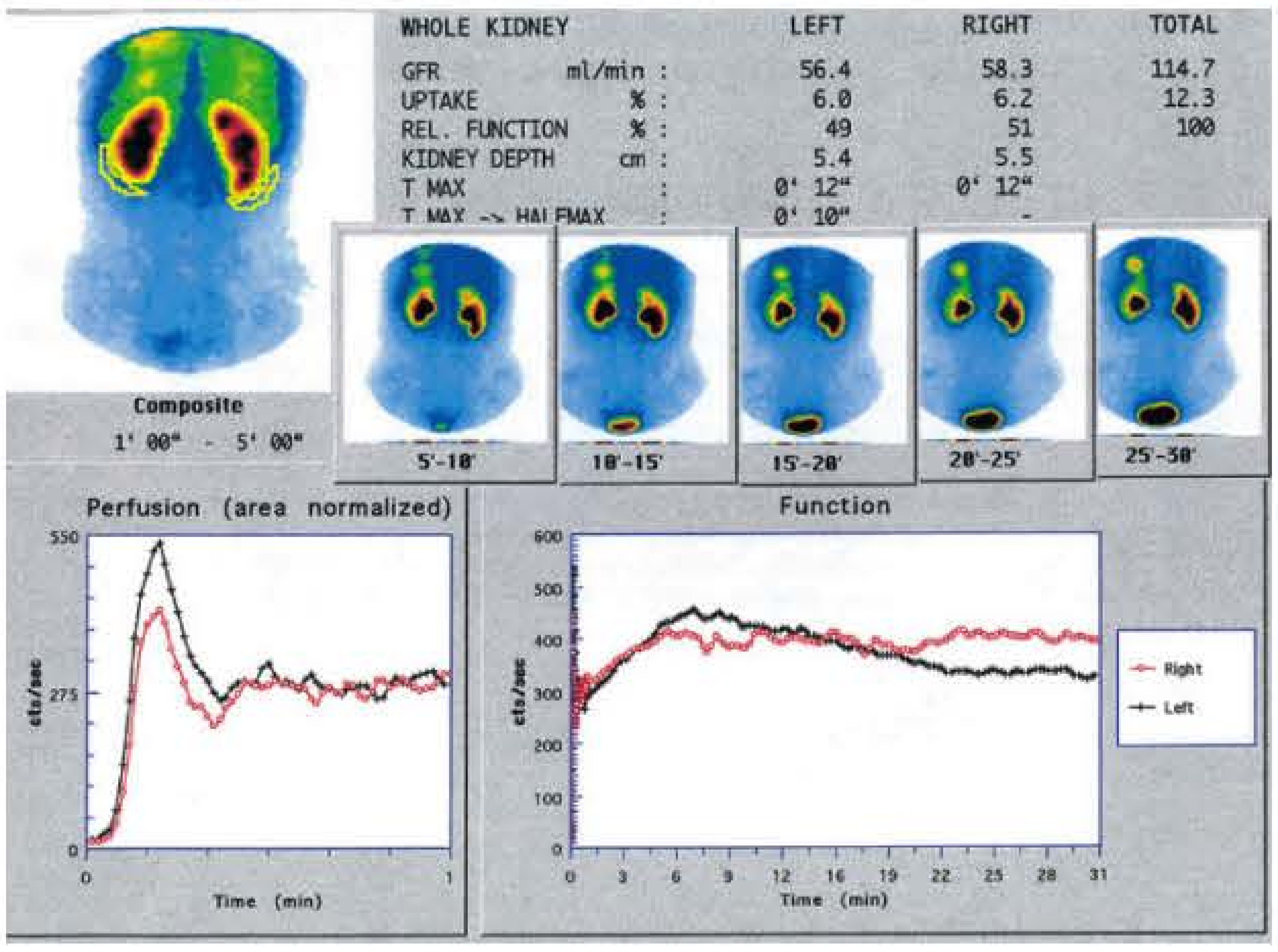


FIGURE 5.25 **Patient with UPJ stenosis operated antegradely.** IVU before the intervention (a) and 1 month after surgery (b).

Thus, in a study published in 1990, Clayman compares the results of the antegrade approach with the retrograde one, achieving relatively comparable success rates (79% for antegrade approach vs. 78% for the retrograde one), but with a shorter period of maintaining the nephrostomy in the case of retrograde endopyelotomy (3 days vs. 4 days). Postoperative analgesic requirements and the higher incidence of ureteral stenoses after retrograde intervention (20%) tips the balance toward the antegrade approach (Clayman et al., 1990).

The use of larger diameter stents does not determine better results compared to the 7 F ones, which are much easier to position and are cheaper. The use of a larger diameter stent causes healing of the incised area with a more pronounced fibrosis, especially in the muscular layer.

The medium- and long-term (72 months) results of antegrade endopyelotomy indicate a success rate of 83.3%. Rigorous selection of patients (judicious assessment of the degree of hydronephrosis and of aberrant vessels) contributes to the increase in the success rate (Zucconelli et al., 1997).



WHOLE KIDNEY		LEFT	RIGHT	TOTAL
GFR	ml/min :	56.4	58.3	114.7
UPTAKE	% :	6.0	6.2	12.3
REL. FUNCTION	% :	49	51	100
KIDNEY DEPTH	cm :	5.4	5.5	
T MAX	:	0' 12"	0' 12"	
T MAX -> HALFMAX	:	0' 10"	-	

FIGURE 5.26 **Renal scintigraphy with isotopic nephrogram 6 months postoperatively after bilateral UPJ stenosis operated sequentially.** Curves with a slower washout of the radiotracer, but without obstruction.

Percutaneous endopyelotomy in children with secondary UPJ stenosis is controversial. However, the published results of a study evaluating the results of percutaneous endopyelotomy in children with UPJ stenosis secondary to a Hynes Andersson-type pyeloplasty demonstrated a high success rate (88%) (Capolicchio et al., 1997).

In cases in which antegrade endopyelotomy failed, encouraging results were obtained by retrograde procedures, laparoscopic or, as a last resort, open surgery.

An important and poorly studied aspect in the endoscopic treatment of UPJ stenoses is the financial one. Determining the optimal therapeutic conduct cannot be dictated by costs, but only by the particularities of the case. A comparison of the costs of an endoscopic intervention with those of an open surgical or laparoscopic intervention highlighted the reduced cost of endopyelotomy compared to classic or laparoscopic procedures (Gettman et al., 2003) (Table 5.1).

The variables included in the calculation of an intervention's costs were represented by the duration of the surgery and hospitalization, cost of equipment, and the success rate. The most efficient interventions in terms of cost-effectiveness are ureteroscopic endopyelotomy and the one with the Acucise catheter. It is worth noting the relatively similar costs of the reconstructive interventions: open surgery and laparoscopic interventions, respectively. It was also observed that Acucise endopyelotomy, which many considered to be the most expensive due to the cost of the Acucise catheter, has a lower cost than the antegrade approach. This is practically the only method of "blind" incision, with relatively modest results, but is still performed in many centers in the world especially because it is an easy maneuver and due to the short hospitalization period (Gettman et al., 2003; Hemal et al., 2003).

A comparative table with data from the literature regarding endourological treatment of UPJ stenosis according to the type of stenosis is summarized in Table 5.2.

The very good success rates of endoscopic procedures for the treatment of UPJ stenosis can be observed, the choice of the therapeutic method practically depending on the equipment and on the technique mastered. However, the best results are obtained after laparoscopic pyeloplasty.

Antegrade endopyelotomy is recommended for secondary UPJ stenoses after pyeloplasty (Figenshau et al., 1996), with a success rate of 60% for primary stenoses and of 87% for secondary ones, over a 60-month follow-up period.

In another study, in case of primary stenoses the success rate of antegrade endopyelotomy after the first intervention was of 89%, and increased after an iterative intervention to 91%. Thus, the authors consider that by performing antegrade endopyelotomy, it was possible to avoid open surgery in 86% of patients with primary UPJ stenoses. Endopyelotomy is less invasive, has very good esthetic and functional effects, and is a repeatable method that does not exclude an eventual open surgery if endoscopy fails (Danuser et al., 1998).

TABLE 5.1 Comparative Analysis of the Costs for an Intervention for a UPJ Stenosis

Cost	Retrograde ureteroscopic endopyelotomy	Antegrade endopyelotomy	Endopyelotomy with Acucise catheter	Laparoscopic pyeloplasty	Surgical pyeloplasty
USD	3842	5297	4427	7026	7119

TABLE 5.2 Summary of the Key Studies Published in the Literature Regarding the Outcomes of Endoscopic Treatment in UPJ Stenosis

Author	Cases	Approach	Type	Success (%)	Follow-up (months)
Meretyk et al. (1992)	41	Antegrade Retrograde		79 78	
Kletscher et al. (1995)	50	Antegrade	Primary Secondary	90 82	
Netto (1996, children)	9	Antegrade	Primary Secondary	83 80	42
Figenshau (1996)		Antegrade	Primary Secondary	61 100	60
Zucconelli et al. (1997)	24	Antegrade		83.3	12–72
Umekawa (1997)	6	Acucise		66.7	20
Capolicchio et al. (1997, children)	9	Antegrade	Secondary	88.9	72
Danuser et al. (1998)	80	Antegrade	Primary	89–91	26
Kohler (1997)	48	Antegrade (21) Retrograde (24)	Primary (43) Secondary (5)	81	120
Jabbour et al. (1998)	72	Antegrade	Secondary	87.5	88
Devevey (1999)	13	Retrograde	Primary (10) Secondary (3)	84.6	24
Bernardo and Smith (1999, retrospective study)	400	Retrograde Acucise Horseshoe kidney		79–84 64–79 78	
Biyani (1997)			Laser	87.5	12
Giddens and Grasso (2000)	28	Retrograde Laser	Primary (20) Secondary (8)	83	
Knudsen et al. (2004)	80	Antegrade (Laser 3)	Primary (61) Secondary (19)	65 74	55
Brito et al. (2002)	30	Acucise		86.6	
Shilo et al. (2005)	67	Antegrade (15) Retrograde (52)		94 93	
Minervini et al. (2006)	61 (68 procedures)	Antegrade (19) Retrograde (49) Laser	Primary (39) Secondary (29)	64 68 80	
Janetschek et al. (1996)	14	Laparoscopic	Pyeloplasty Ureterolysis	100 50	
Bauer et al. (1999)	42 42	Laparoscopic Classic		90 91	24
Soulie et al. (2001, multicentric study)	55	Laparoscopic		87	3
Jarrett et al. (2002)	100	Laparoscopic	Primary (83) Secondary (17)	90	36
Pardalidis et al. (2002)	8 14	Laparoscopic Antegrade		100 92.8	12
Baldwin et al. (2003)	9 16 7	Acucise Laparoscopic Surgical		56 94 86	24
Singh et al. (2009)	34 26	Laparoscopic Antegrade		91.2 88	36 39

A study published in 2004 by Knudsen showed a lower long-term success rate for antegrade endopyelotomy (67%), the median time to relapse being 15 months. Relapses were particularly associated with the presence of polar vessels. Therefore, avoiding endoscopic approach in these cases, as well as long-term active surveillance of the patients, is recommended (Knudsen et al., 2004).

Recently, other authors have objectified comparable success rates between antegrade endopyelotomy (92.8%) and laparoscopic pyeloplasty (100%), concluding that the endoscopic approach is a treatment of choice for patients with idiopathic UPJ stenosis. Although laparoscopic interventions have better results, the technique is much more laborious (Pardalidis et al., 2002).

5.5 COMPLICATIONS

Antegrade endopyelotomy is a procedure associated with low morbidity, but with a variety of complications that any urologist should consider.

Urological complications of antegrade endopyelotomy generally fall into two categories: those related to the percutaneous access (most often the most severe) and those directly related to endopyelotomy.

Bleeding secondary to vascular damage is the most feared complication of endopyelotomy (Bellman, 1996). Fortunately, it is uncommon, blood transfusions being necessary in 1–9% of antegrade endopyelotomies (Motola et al., 1993a; Kuenkel and Korth, 1990). These injuries can occur while creating the percutaneous tract or during the incision of the UPJ. To prevent their occurrence, any pulsatile structures should be avoided when viewing the UPJ and the incision redirected if any vascular elements are observed.

If conservative measures fail to stop the bleeding, selective angiographic embolization is indicated. This is usually successful, thus avoiding the need for surgical exploration or even an emergency nephrectomy.

Also, arteriovenous fistulas secondary to antegrade endopyelotomy have been reported (Meretyk et al., 1992; Malden et al., 1992).

Since the duration of the intervention is relatively short, complications related to fluid absorption are rare. Urosepsis may occur in 2–4% of patients undergoing endopyelotomy (Bellman, 1996).

Other major complications, rarely encountered, include ureteral avulsion or ureteral necrosis, urinoma, nephrocutaneous fistula, as well as accidental incision at the site of narrowing of the infundibulum or renal pelvis (Bellman, 1996).

Stent-related complications include migration, calcification, and obstruction. These may require repositioning or replacement of the stent (Fig. 5.27).

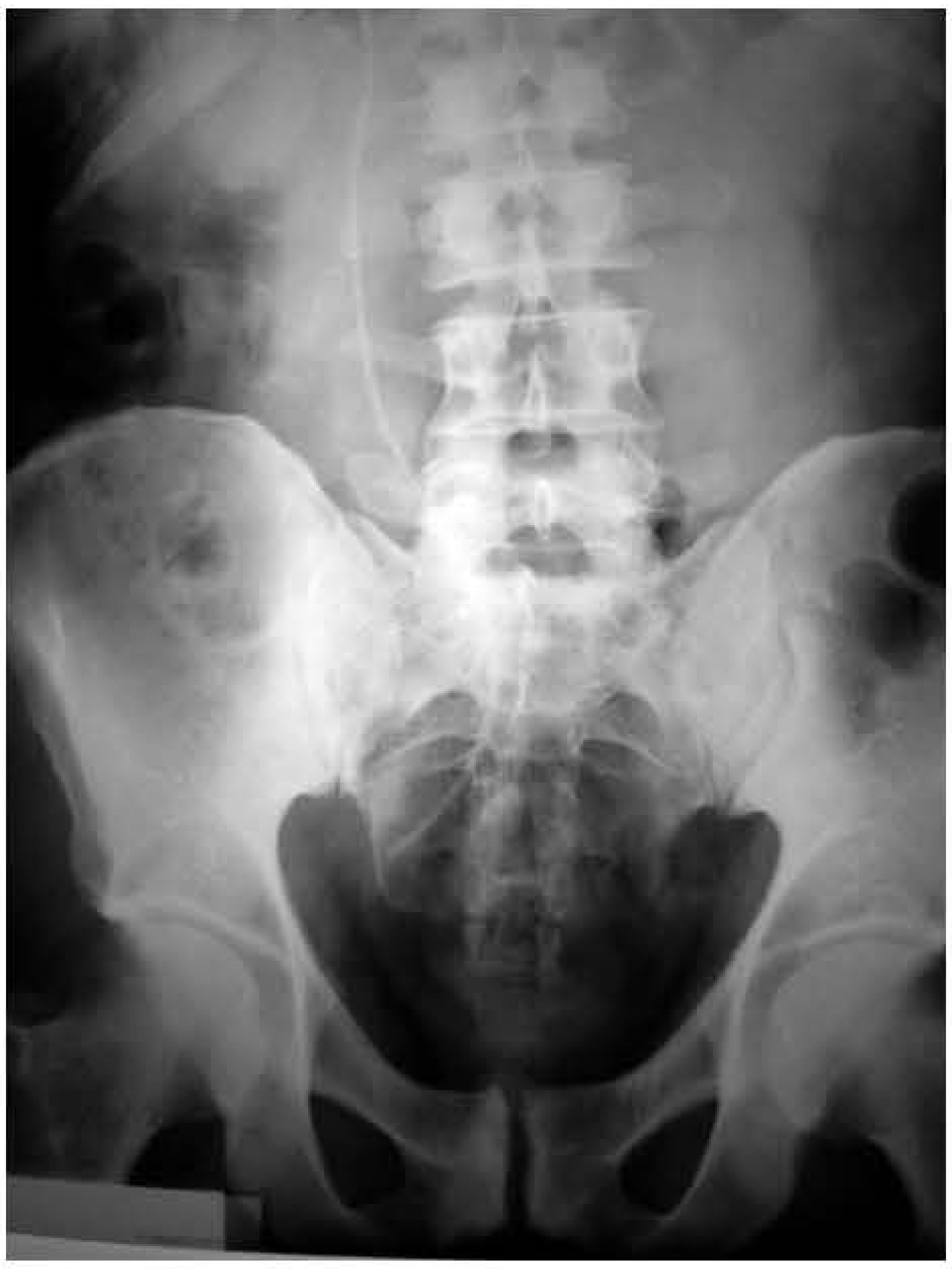


FIGURE 5.27 **Stent migrated upward (aspirated) 48 h after antegrade endopyelotomy.**

Persistence of the obstructive syndrome may occur in the immediate postoperative period, mainly due to the presence of the ureteral stent. Rarely, the stent may be obstructed by blood clots, requiring maintaining the nephrostomy tube for several days until the lysis of the clots and the stent's permeability are restored.

Another possible complication of the presence of the ureteral stent is the occurrence of vesicoureterorenal reflux that may prolong bladder catheterization. Precautionary measures such as preoperative urine sterilization or prophylactic antibiotics may reduce the incidence of infectious complications.

The complications of antegrade endopyelotomy which appear especially during the percutaneous approach are represented by: pleural lesions (pneumothorax), hemothorax and pleural effusion, colon perforation, perforation of the duodenum, damage to the spleen and liver, pancreatitis (Reynard et al., 2008).

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CHAPTER

6

Percutaneous Approach in Ureteral Pathology

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6.1 GENERALITIES

The introduction of the percutaneous approach (Fernstrom and Johansson, 1976) and the subsequent development of this technique determined substantial changes regarding the management of renal and ureteral pathology (Clayman et al., 1984). Antegrade ureteroscopic approach may represent, in selected cases, a viable therapeutic alternative for proximal ureteral stones. Choosing one of the currently available treatment options is influenced by a number of factors: equipment, the surgeon's training, and the patient's option.

The percutaneous treatment of ureteral stones was first mentioned by Smith and coworkers in 1979. Initially, the removal of ureteral stones was attempted by antegrade insertion of the basket catheter followed by the stone's extraction under fluoroscopic control. The progress made regarding the miniaturization of endoscopes, the development of percutaneous approach techniques, the appearance of flexible instruments, and of new energy sources used for stone lithotripsy improved the efficiency and safety of this technique in carefully selected cases, being used as a first-line alternative.

The percutaneous insertion of the ureteroscope into the proximal ureter allows performance of therapeutic maneuvers from the pyeloureteral junction to the level of the L5 vertebra (Streem et al., 1988; Anselmo et al., 1990). The dilation of the suprajacent urinary tract allows for the easy insertion of the rigid or flexible ureteroscope up to the stone (Fig. 6.1), as well as its processing and extraction (Andreoni et al., 2001).

6.2 INDICATIONS

The therapeutic alternatives for stones located in the proximal ureter have suffered important changes with the introduction of ureteroscopy and extracorporeal lithotripsy (SWL) (Drach et al., 1986; Blute et al., 1988).

Currently, due to the progress regarding extracorporeal lithotripsy and to the perfectioning of retrograde approach, antegrade ureteroscopy has limited and very precise indications (Pearle et al., 1998; Lam et al., 2002):

- impacted (for over 4 weeks), large (>1 cm) lumbar ureteral stones (Fig. 6.2)
- ureteral stones in which the retrograde approach is difficult or impossible (urinary diversions, etc.)
- large proximal ureteral stones that cannot be fragmented by SWL
- patients with SWL contraindication
- multiple lumbar ureteral stones
- lumbar ureteral steinstrasse
- completely obstructive proximal ureteral stones with nonfunctioning kidneys on IVU
- large calcifications of the proximal end of a neglected JJ catheter
- associated reno-ureteral lithiasis

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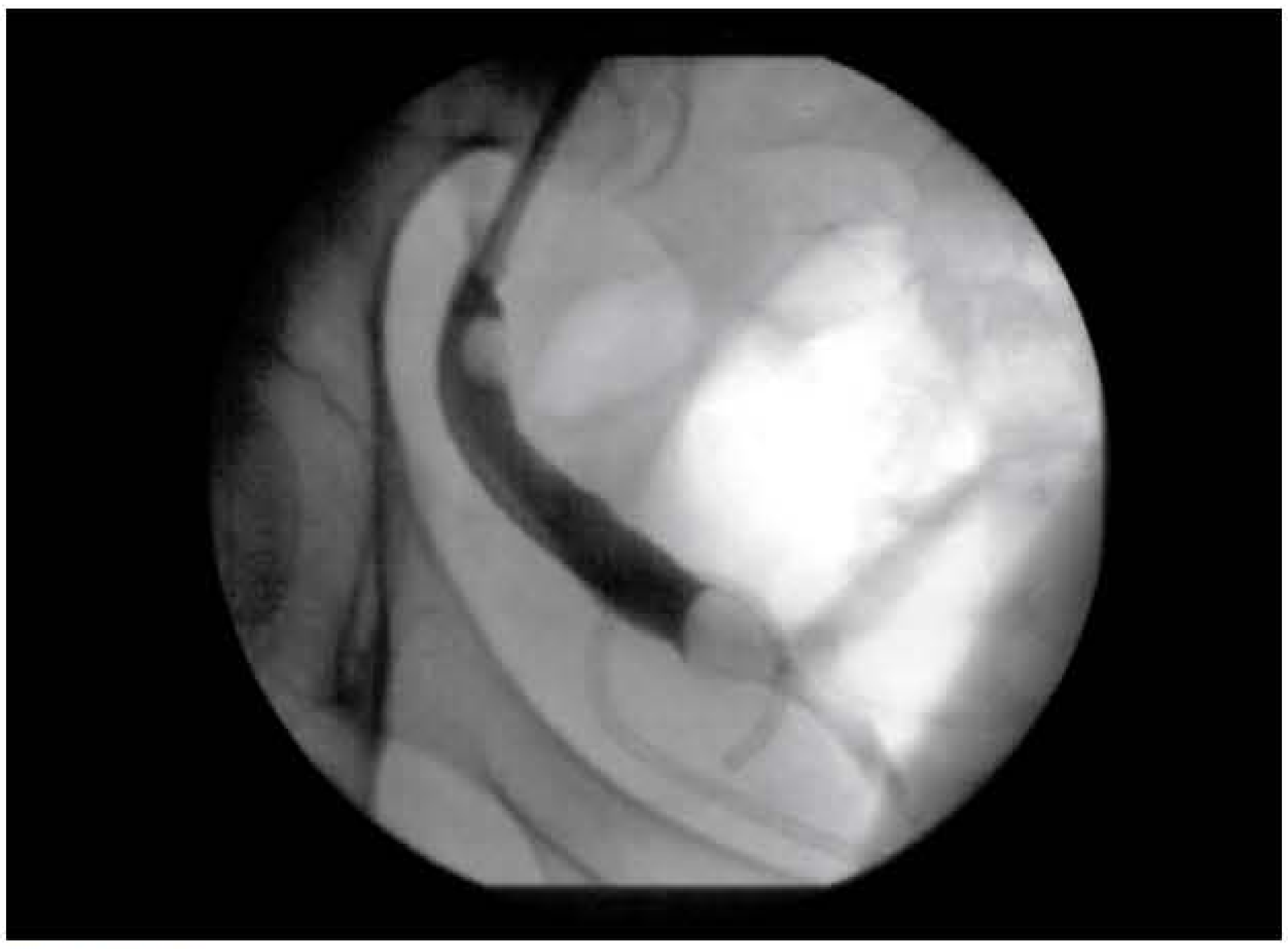

FIGURE 6.1 Flexible antegrade ureteroscopy for a large pelvic ureteral stone (fluoroscopic aspect).

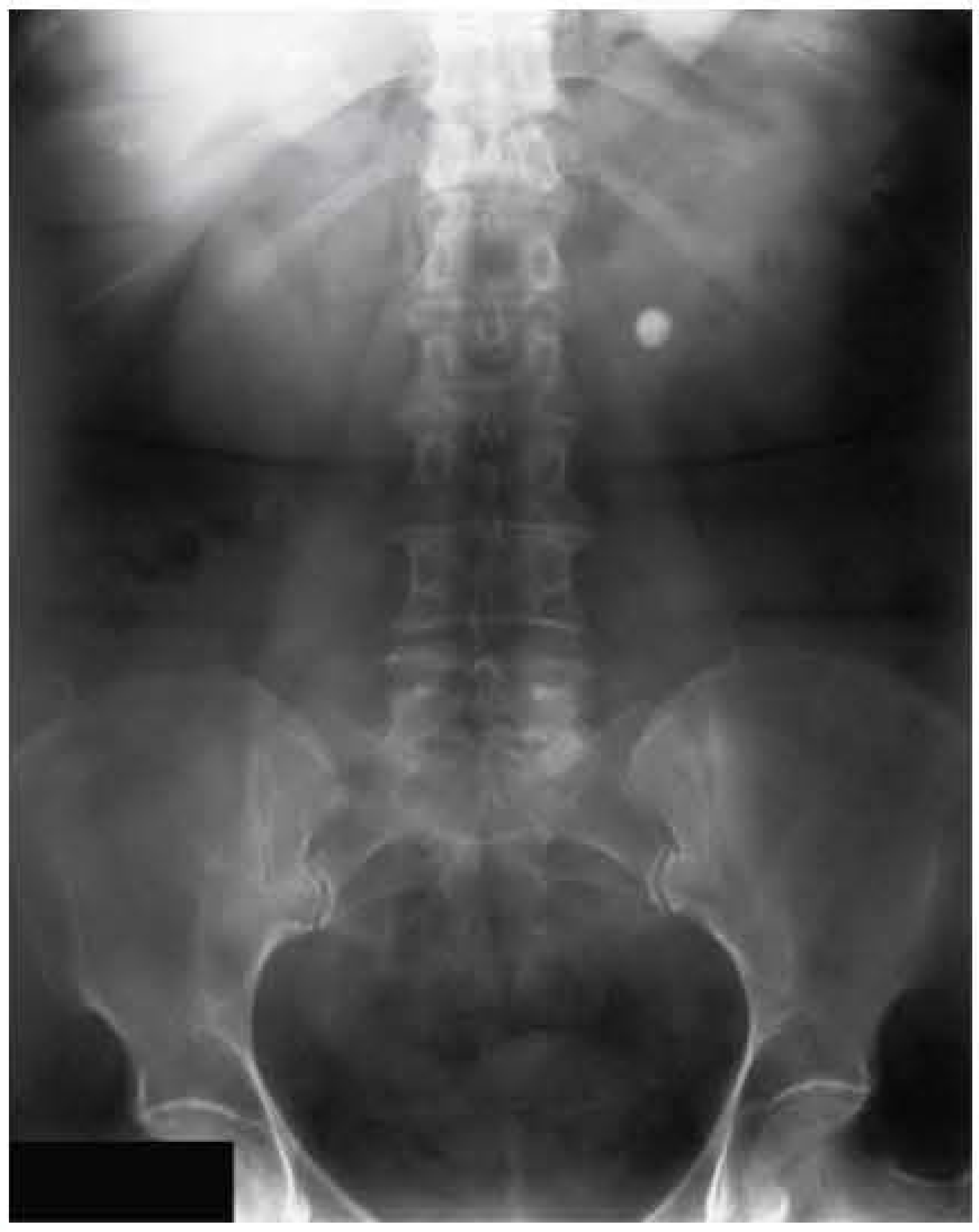

FIGURE 6.2 Large lumbar ureteral stone (simple reno-vesical radiography).

Although proximal ureteral stones larger than 1 cm may benefit from SWL, the success rates are relatively low, with a high number of reinterventions. At the same time, the ureteroscopic approach (especially flexible) for proximal ureteral stones allows achievement of high "stone-free" rates, with a minimal morbidity (Lam et al., 2002). However, for selected cases with impacted, large (over 1 cm) proximal ureteral stones, antegrade management may represent the most efficient and adequate treatment option. The procedure allows for the intact removal of the stones, thus avoiding repeating the procedure for potential residual lithiasic fragments (relatively frequently encountered in the case of retrograde approach for such cases). Also, the use of high-caliber instruments allows for the efficient removal of large stone fragments (Fig. 6.3). Completely obstructive ureteral stones, regardless of their localization, that associate suprajacent urinary infection, usually will not be treated as a first intention. The percutaneous approach of the kidney ensures a proper drainage and offers the possibility for antegradely placing a JJ catheter that will facilitate the ureteroscopic access at the right moment.

In certain situations (uretero-vesical reimplantation, urinary diversions, associated ureteral strictures), the retrograde ureteroscopic approach may be difficult or impossible (Liong et al., 1989) (Fig. 6.4). Also, in these cases the "stone-free" rate after SWL is reduced due to the difficult elimination of stone fragments, thus contributing to the use of the antegrade ureteroscopic approach as a first line of treatment. Patients with ureteral stenosis and a large suprajacent stone may benefit from the percutaneous approach of the associated stone with endoureterotomy. Ureteral lithiasis in patients with urinary diversions may represent a challenge for the retrograde endoscopic approach, due to the absence of the known anatomic landmarks. Stenosis of the ureteral anastomoses favors the occurrence of lithiasis but, in equal measure, hinders the retrograde ureteroscopic approach. The antegrade ureteroscopic approach, flexible or semirigid, offers a safe and efficient therapeutic alternative in these cases (Delvecchio et al., 2000). For complex cases, there is the possibility of performing a combined retrograde and antegrade approach for a better visualization and a better processing of the lithiasic masses. Some authors describe the use of the antegrade approach exclusively for performing a ureteropyelography, which will subsequently allow for the correct retrograde approach of the respective ureter.

If flexible ureteroscopy is not accessible, the percutaneous approach represents a viable alternative for treating large proximal ureteral stones that cannot be resolved by extracorporeal lithotripsy.

Rough stones (cystine, calcium oxalate monohydrate) have a low "stone-free" rate after SWL (Lingeman et al., 1987). The retrograde approach may represent an alternative for these cases, but its failure represents an elective indication for using antegrade ureteroscopy (Mulțescu et al., 2007).

The association between ureteral and renal lithiasis (especially in the case of renal stones larger than 2.5 cm, or lower caliceal stones larger than 1.5 cm) represents an important indication for the percutaneous approach (Fig. 6.5), due to the possibility of simultaneously resolving both the ureteral and the renal stones in a single session (Henriksson et al., 1989; Geavlete et al., 2007a).

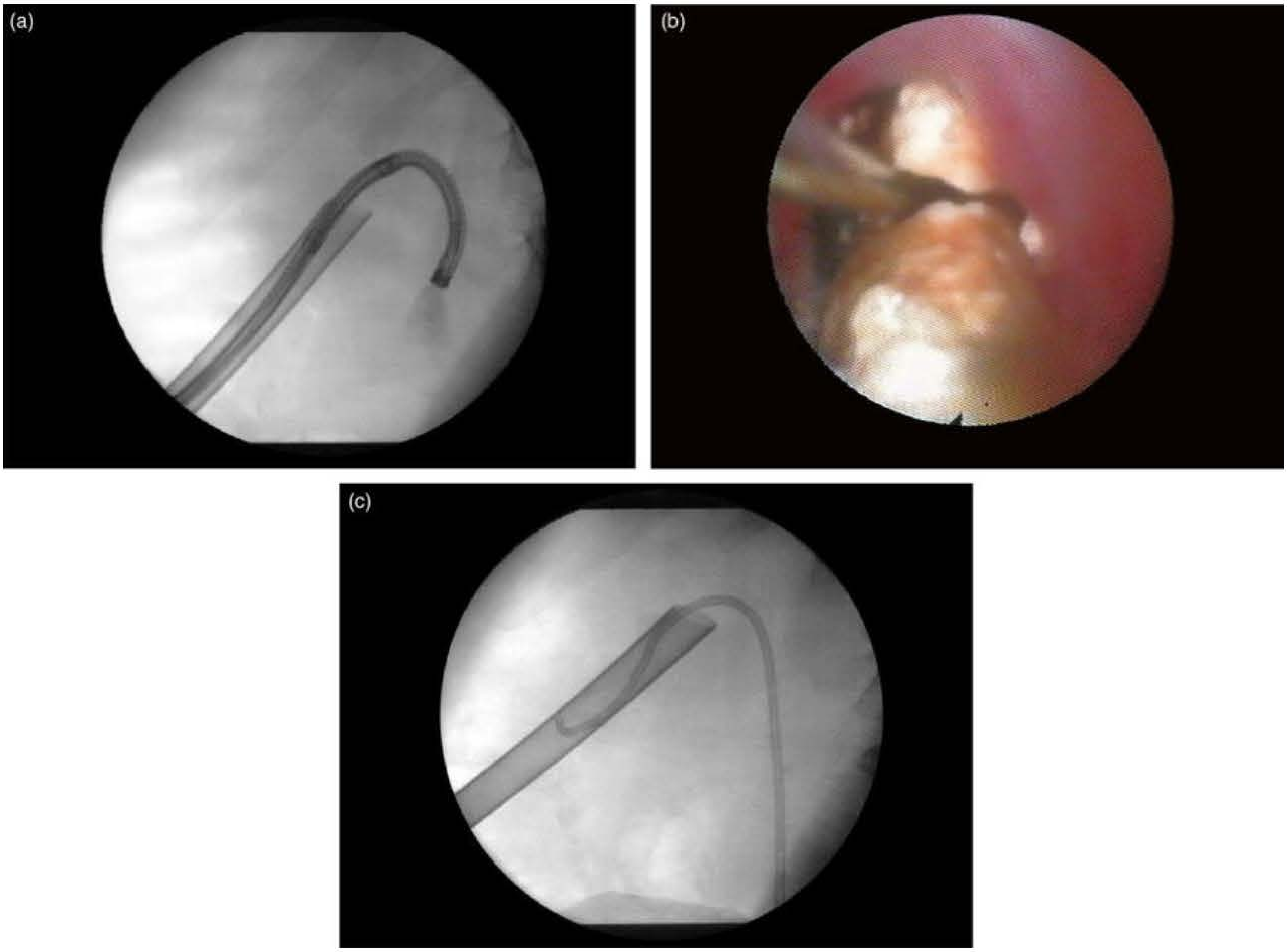

FIGURE 6.3 **Large lumbar ureteral stone.** (a) Percutaneous approach using the flexible nephroscope (intraoperative fluoroscopy); (b) electrohydraulic lithotripsy of the stone; and (c) "stone-free" aspect at the end of the intervention and antegrade placement of a JJ catheter.

Another indication is represented by patients with complications occurring during retrograde ureteroscopy (ureteral perforations distal to the stone). Also, in the case of an impacted ureteral stone, with important hydronephrosis and suprajacent infection, placing a nephrostomy tube may represent a first therapeutic step (Pearle et al., 1998). The antegrade approach of such cases may be preferred to the retrograde approach due to the advantage provided by the existence of a nephrostomy tract (Yagisawa et al., 2001).

A special indication, recently described by Ruggera, refers to patients with multiple calcium oxalate stone recurrence, in whom it is considered that lithogenesis is explained by the attachment of urine crystals on the calcium phosphate deposits in the interstitium. The resulting structure is a precursor of the Randall plaques, first described in 1937, which are precursors of renal stones. Biopsy of the renal papilla may show the existence of prelithiasic structures that would lead to more complex treatments for preventing recurrences. The technique consists of the percutaneous approach of the kidney, performing multiple biopsies, after which the intervention continues to resolve the acute lithiasic episode, using the antegrade approach (Ruggera et al., 2011).

Some authors recommend the use of the antegrade approach for treating proximal ureteral stones in small children, thus avoiding retrograde ureteroscopy that may be very difficult due to the low ureteral caliber (Mor et al., 1997).

The contraindications of antegrade ureteroscopy are similar to those of percutaneous nephrolithotomy, including hemorrhagic diatheses, the impossibility of positioning the patient, or of obtaining a safe approach of the pyelocaliceal system.

In the case of proximal ureteral lithiasis, antegrade ureteroscopy presents a series of advantages compared to the retrograde approach. The treatment of a large lumbar ureteral stone by retrograde ureteroscopy may be difficult due to the difficulties in ascending the ureteroscope, the risk of fragment migration during the lithotripsy maneuvers, as

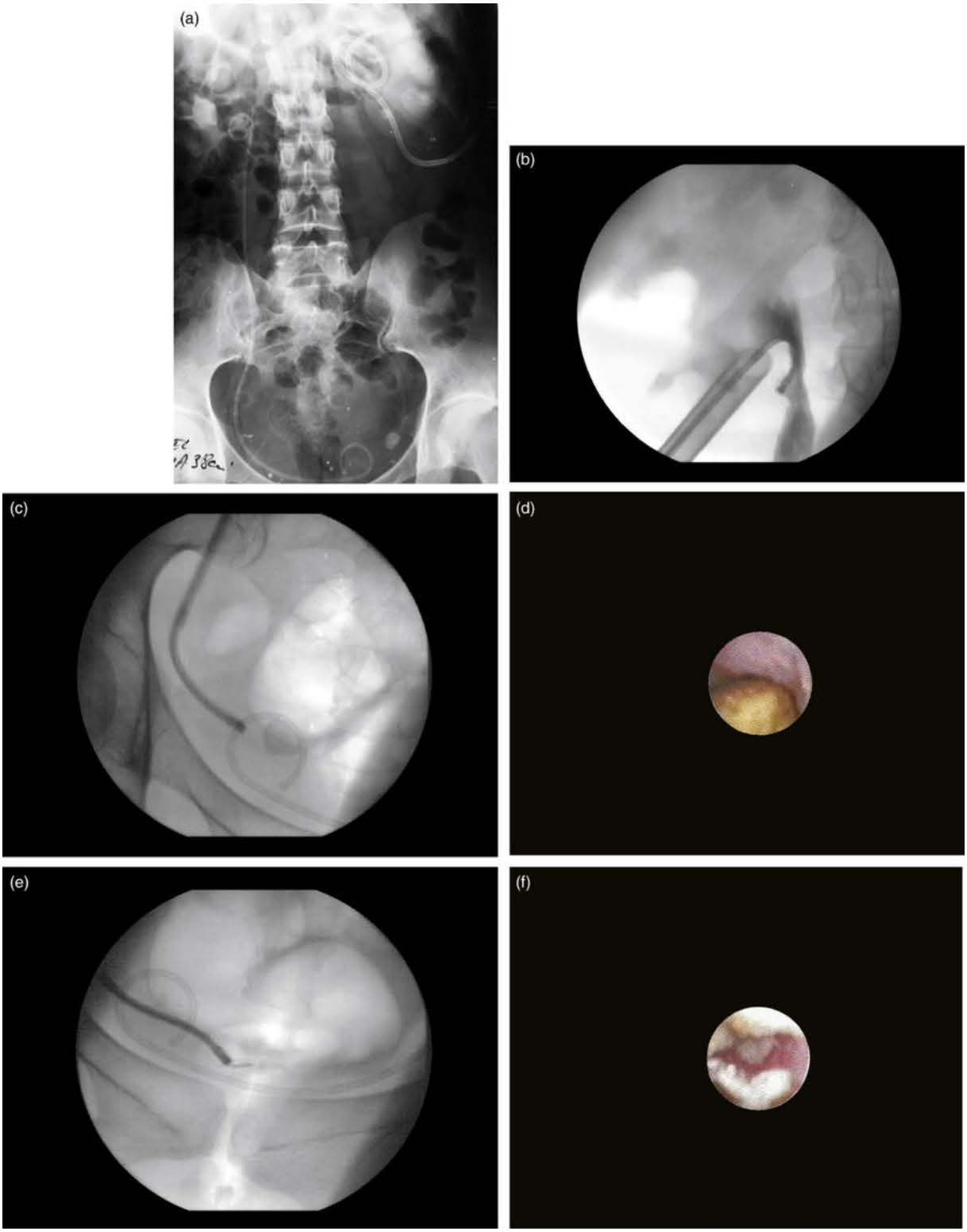

FIGURE 6.4 **Antegrade approach for a large left pelvic ureteral stone in a patient with uretero-vesical reimplantation.** Preoperative simple reno-vesical radiography (a); lower caliceal antegrade approach (b); antegrade ureteroscopy (c); ureteral stone detection (d); its electrohydraulic lithotripsy (e–h); entering the urinary bladder (i); and "stone-free" final aspect (j).

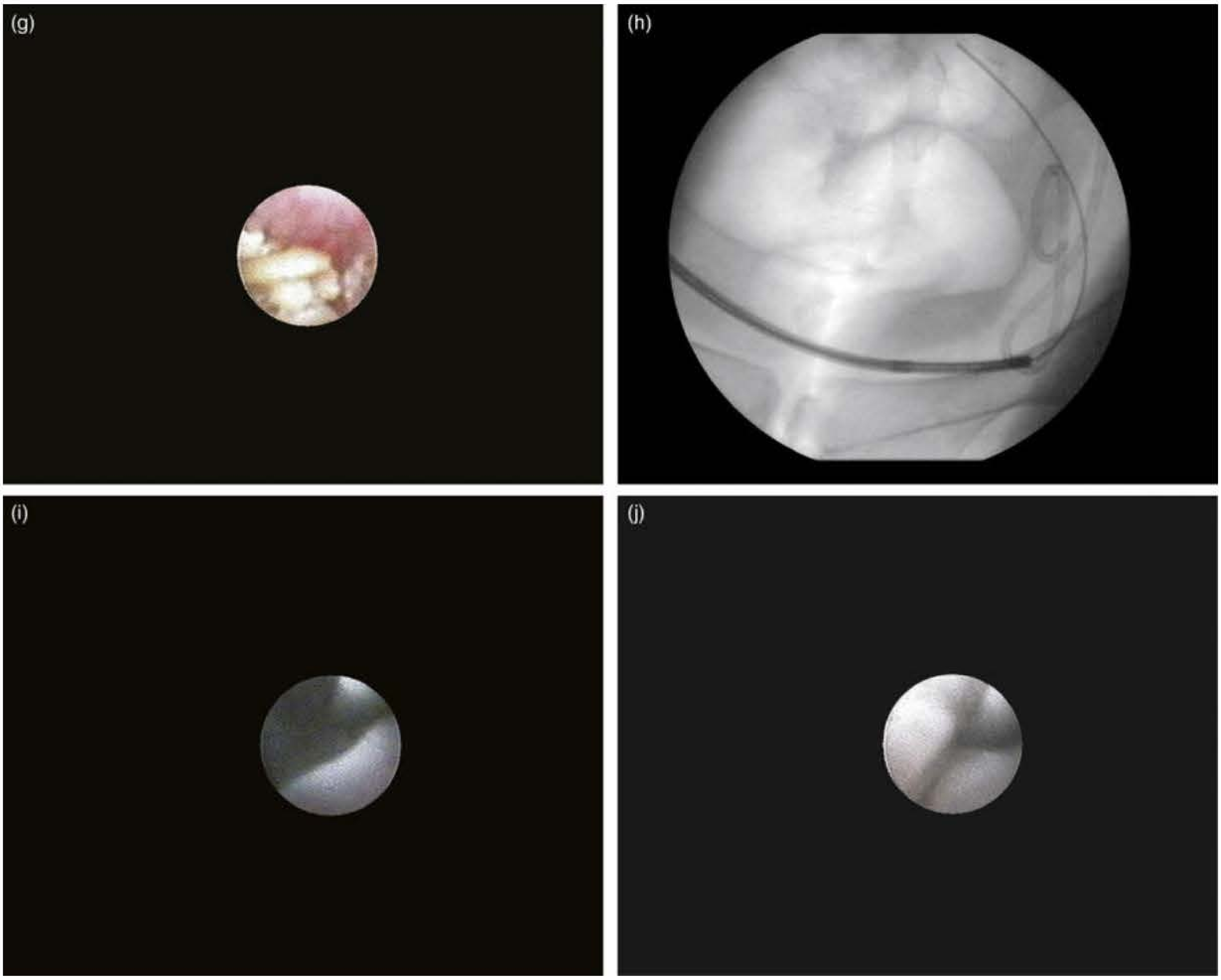

FIGURE 6.4 *(Cont.)*

well as the potential complications that occur during the extraction of large lithiasic fragments. Therefore, antegrade ureteroscopy may represent an efficient method in treating lumbar ureteral lithiasis. After creating a proper puncture tract, the instruments can be easily inserted into a ureter that is dilated due to the lithiasic obstacle. Antegrade ureteroscopy may be performed with very good visibility, without the risk of renal hyperpressure.

6.3 TECHNICAL ELEMENTS IN ANTEGRADE URETEROSCOPY

The preoperative preparation, anesthesia, and patient positioning on the operating table are identical to those of the percutaneous nephrolithotomy.

Special attention should be paid to obese patients and to those with severe lung diseases, for whom the ventral decubitus position may be difficult or impossible to tolerate. Some authors suggest using flexible retrograde ureteroscopic approach as the first line of therapy in these cases (Andreoni et al., 2001).

The necessary instruments during an antegrade ureteroscopy are more complex, including instruments for the percutaneous approach of the kidney, as well as instruments for the antegrade ureteroscopy itself (Table 6.1).

The first operatory step is represented by urethrocystoscopy with the placement of a ureteral catheter (6 F) that allows injection of the contrast medium for the opacification of the pyelocaliceal system. This is performed with the patient in the lithotomy position.

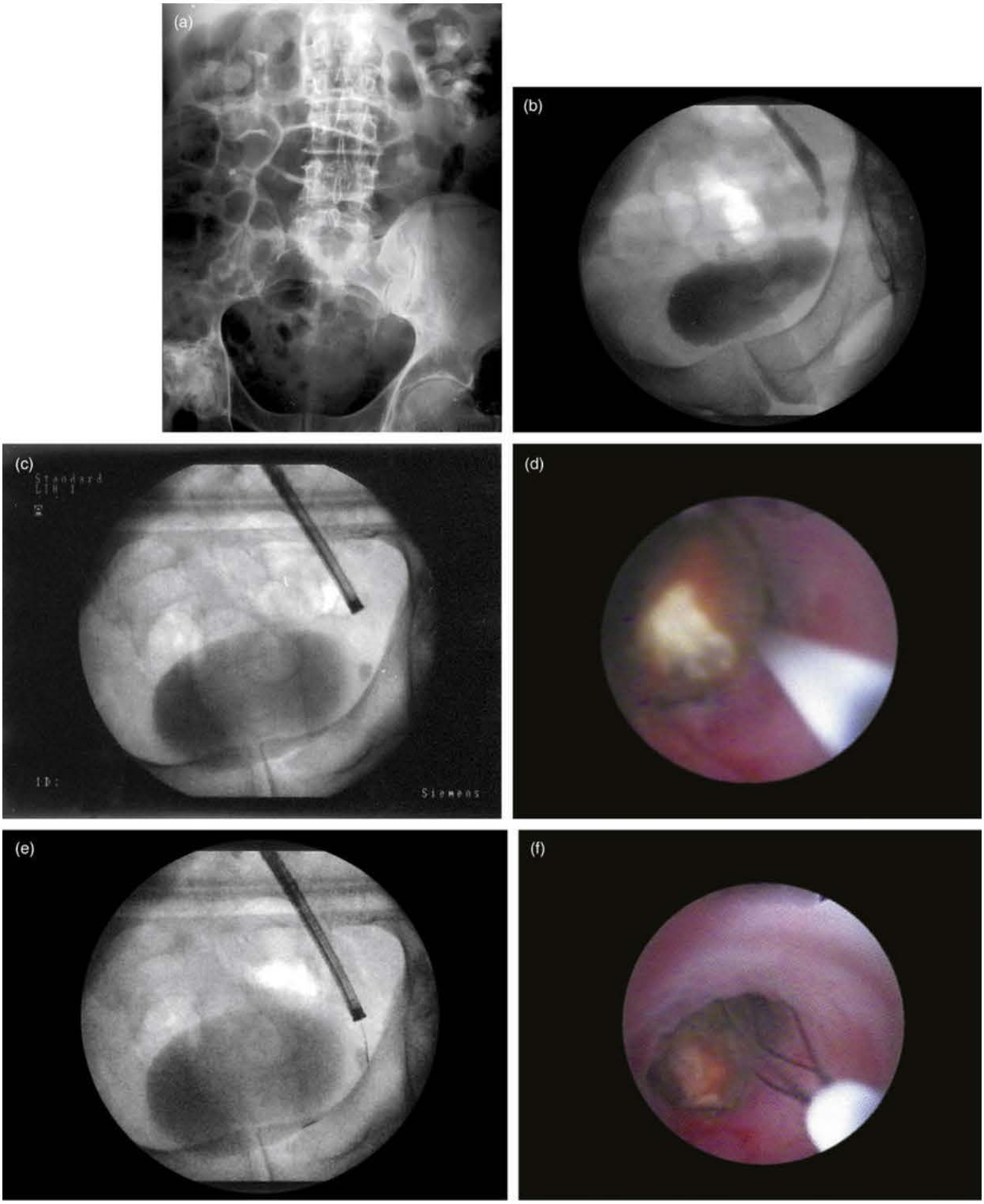

FIGURE 6.5 **Multiple reno-ureteral lithiasis (antegrade approach).** (a) Simple reno-vesical radiography–right pelvic ureteral stone, right caliceal stone, left staghorn stone; (b, c) antegrade approach of the ureteral stone using the flexible nephroscope (intraoperative fluoroscopy); (d–f) ureteral stone extraction using the Dormia catheter; (g) approach of the upper caliceal stone by flexible nephroscopy (intraoperative fluoroscopy); and (h) final postoperative aspect.

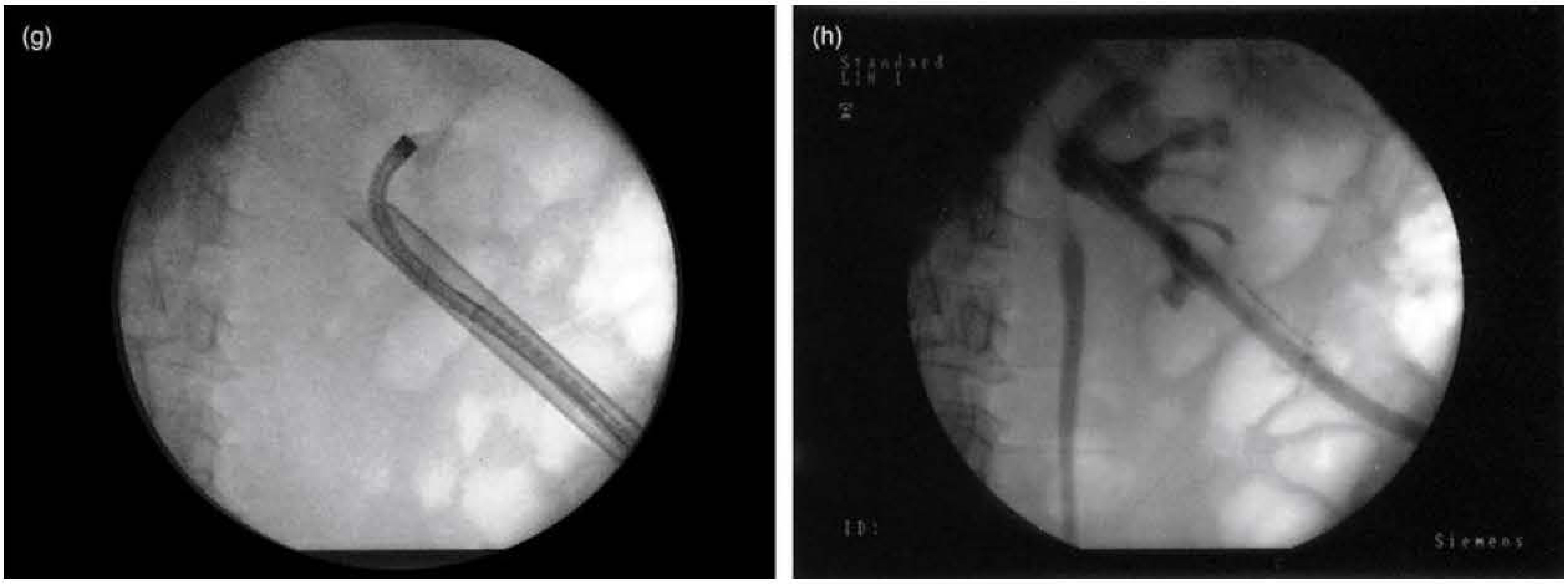

FIGURE 6.5 *(Cont.)*

After locating the stone by fluoroscopy, an attempt can be made, if possible, to push the stone into the renal pelvis. If the stone cannot be moved or surpassed with the ureteral catheter and if the pyelocaliceal system cannot be opacified retrogradely, the percutaneous puncture can be performed either by intravenous injection of the contrast medium or by ultrasonographic guidance. In the case of obstructive ureteral stones associated with infection, a percutaneous nephrostomy is initially recommended, the antegrade ureteroscopic approach being performed on the same tract, after the proper treatment of the infection.

Performing the percutaneous puncture and the antegrade ureteroscopy implies placing the patient in the prone position. When rigid instruments are used, the antegrade approach requires creating a tract as straight as possible between the axis of the punctured calyx, the pyeloureteral junction (UPJ), and the ureter. For this reason, the ideal puncture is most frequently performed through the middle or upper calyx. When using the flexible nephroscope, access through the lower calyx is usually preferred (Fig. 6.6).

After positioning the Amplatz sheath, a rigid nephroscopy is recommended to remove the potential blood clots and to inspect the pyelocaliceal system. If the stone is not visible using the rigid nephroscope, the flexible ureteroscope or nephroscope is inserted.

After inserting the ureteroscope, the UPJ is identified and the instrument is advanced up to the stone (Fig. 6.7). The presence of the ascended ureteral catheter facilitates the visualization of the UPJ and the insertion of the ureteroscope downstream.

TABLE 6.1 Instruments Required for Antegrade Ureteroscopic Approach

Chiba 20 needle
Guidewires • Landerquist • Zebra
Fascial dilators (6–8 F)
Amplatz sequential dilators or Alken metallic dilators or 30 F dilation balloon (Microvasive Nephromax or Cook)
Rigid nephroscope (24–27 F)
Semirigid urethroscope (7–11 F)
Flexible nephroscope (15–16 F); flexible urethroscope
Lithotripsy sources: ultrasonic, pneumatic, ballistic, electrohydraulic, Ho:YAG laser; accessory instruments: forceps, Dormia catheters
Nephrostomy tube: Foley catheter (18–22 F), cope tube, Malecot catheters, etc.
JJ catheters (6–8 F)

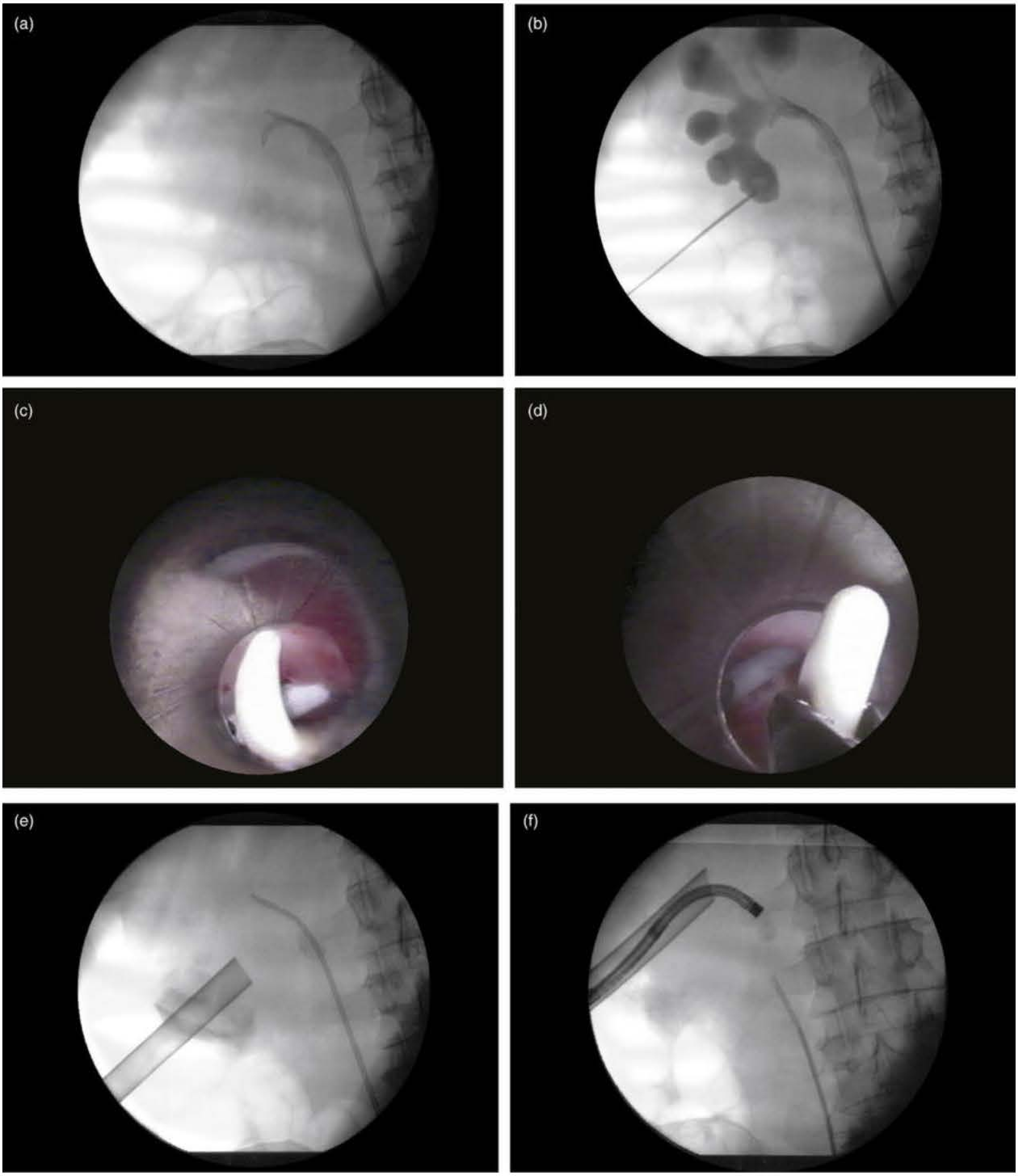

FIGURE 6.6 **The calcification of the JJ stent's proximal end.** Intraoperative fluoroscopy (a); antegrade approach through the lower calyx (b); the antegrade extraction of the JJ catheter (c, d); antegrade approach using the flexible nephroscope (e, f); electrohydraulic lithotripsy (g, h); extraction of antegradely migrated fragments with the basket catheter (i); and final "stone-free" aspect (j, k).

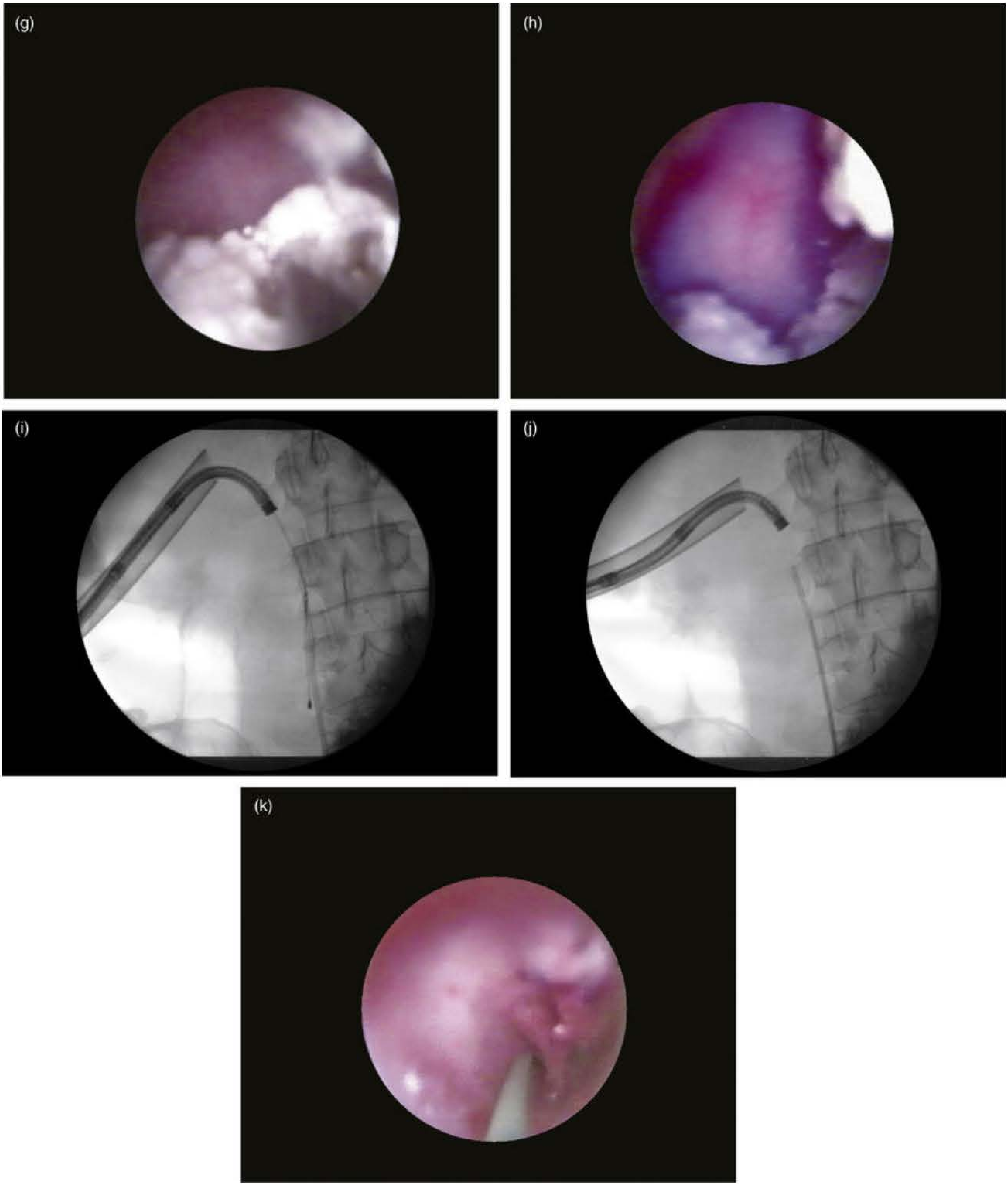

FIGURE 6.6 ***(Cont.)***

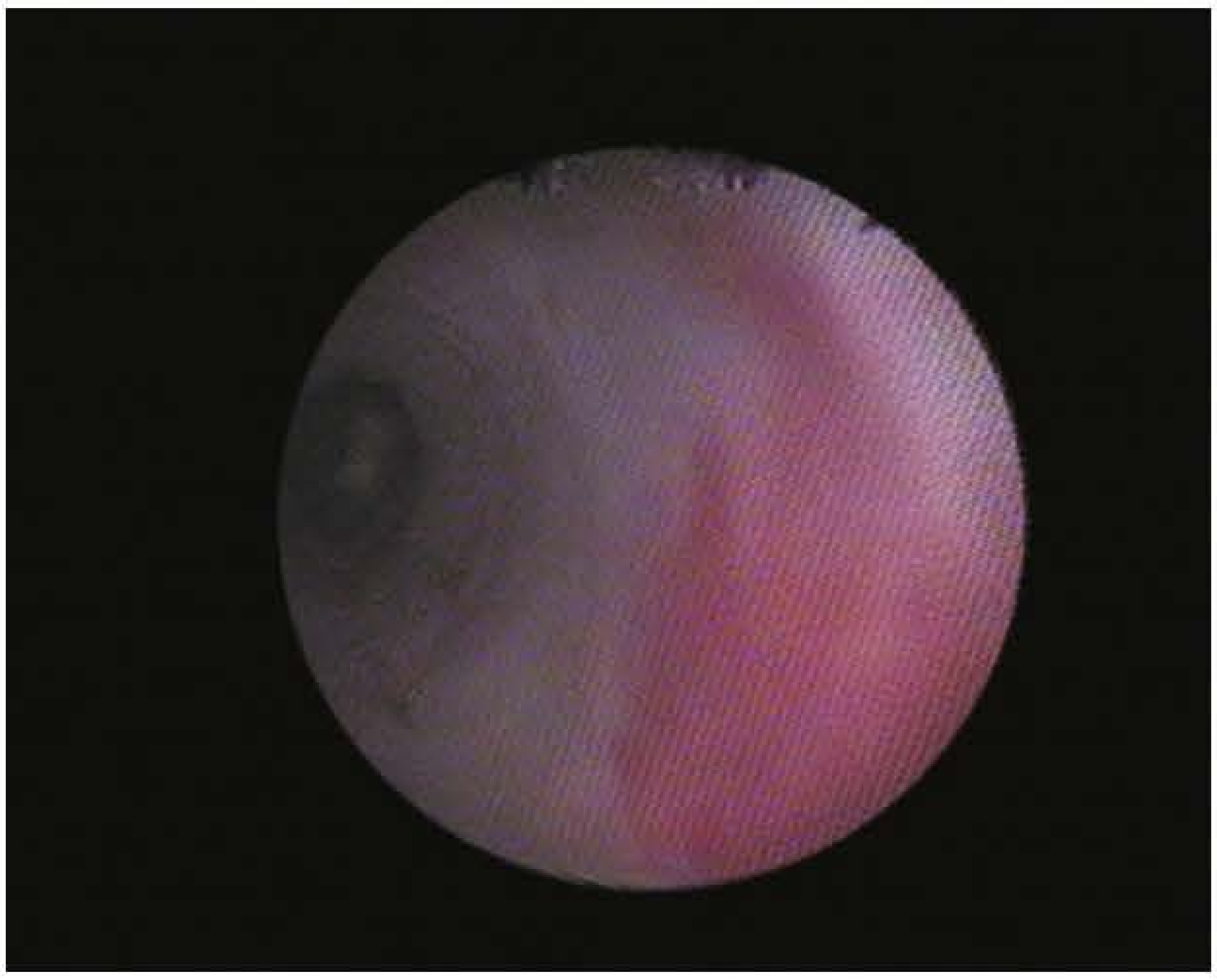

FIGURE 6.7 **Antegrade ureteroscopy – identification of the lumbar ureteral stone.**

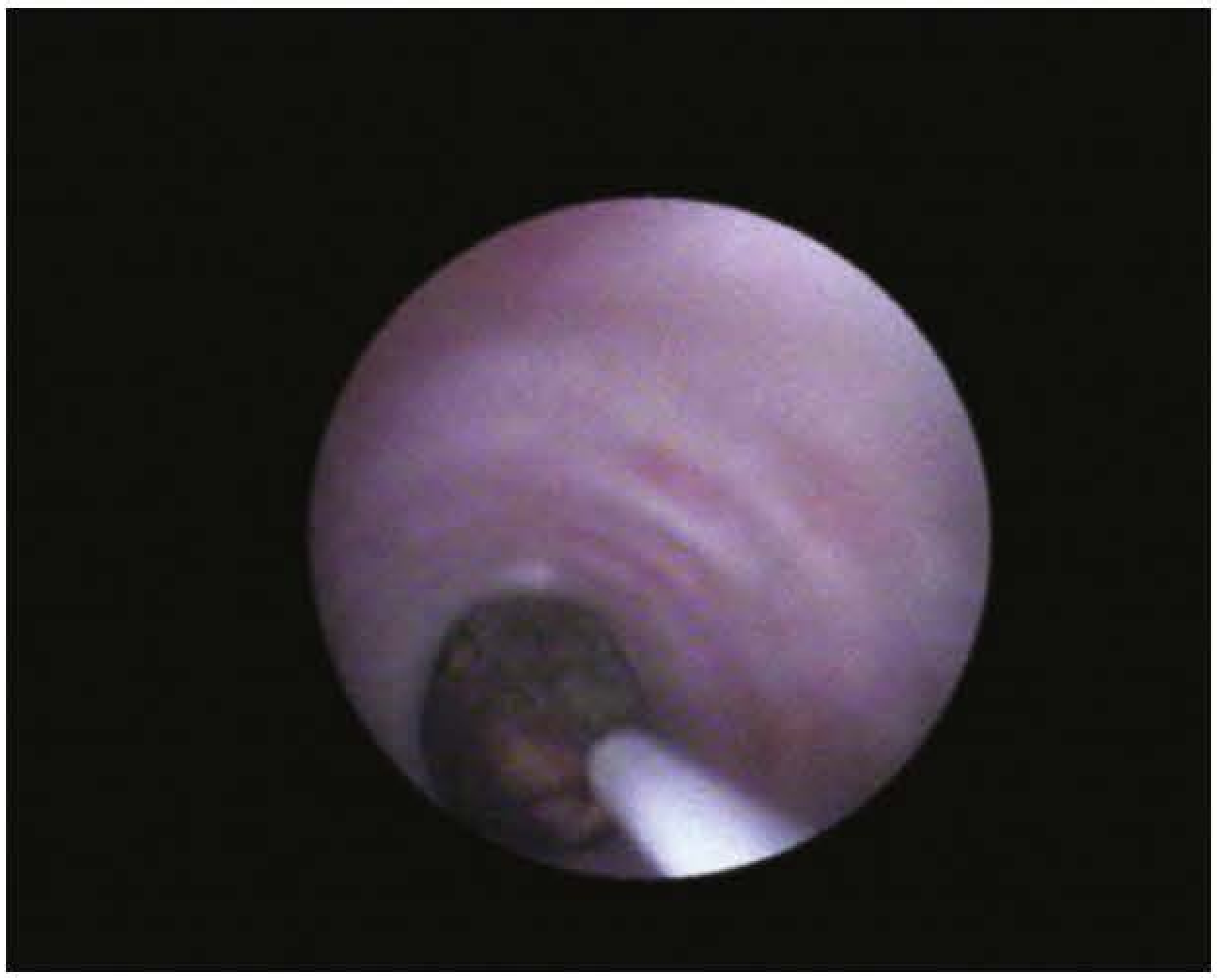

FIGURE 6.8 **Antegrade ureteroscopy – stone extraction using the basket catheter.**

After locating the stone, it is recommended to dislodge and extract it from the ureter with the forceps. Another option is represented by extraction using the basket catheter (Fig. 6.8). Sometimes this maneuver may be difficult, due to the impossibility of overcoming the lithiasic obstacle with the extractor catheter. There is a risk of injuring the mucosa or of ureteral perforations while inserting the catheter or opening the basket. This is why tipless basket extractor catheters made of nitinol are recommended. They do not significantly modify the flexible instrument's deflection, and they are accurate and relatively atraumatic.

After ascending the stone into the renal pelvis, it may be extracted through the nephroscope's sheath or, if the dimensions do not allow this maneuver, lithotripsy between the spires of the probe can be performed (Geavlete et al., 2007b).

Due to the risk of ureteral lesions, the use of the basket catheter has limited indications, the forceps extraction being preferred.

When the stone is too large or impacted in the ureter, the ultrasonic, electrohydraulic, ballistic, or laser fragmentation is required (Auge et al., 2002) (Fig. 6.9). In the case of using flexible instruments, electrohydraulic or Ho:YAG laser lithotripsy is recommended. The holmium:YAG laser represents the flexible lithotripter preferred by most authors because its fibers are small, allowing for a good deflection, it is efficient in treating all types of stones, and if used carefully, determines minimal secondary ureteral lesions.

The resulted fragments may be extracted using a forceps. At the end of the intervention, a flexible nephroscopy is recommended with the careful inspection of the entire collecting system for a potential residual lithiasic fragment.

If ureteral lesions occur during the extraction maneuvers or during the initial ureteroscopy, antegrade placement of a ureteral stent is required (Fig. 6.10). The nephrostomy tube placed at the end of the intervention is maintained, on average, for 48 h. Some authors prefer using a Foley catheter (18–22 F with a 5-cm^3 balloon) with a severed tip, while others prefer 8–10 F cope tubes or Malecot catheters (Feng et al., 2001). Ureteral endoprosthesis after percutaneous nephrolithotomy presents the disadvantage of requiring a secondary intervention performed on an outpatient basis for extraction, but may present the advantage of a shorter hospitalization period.

The use of flexible instruments implies clear advantages, resulting from the fact that the approach of ureteral lithiasis may also be performed after puncturing the lower calyx, a maneuver which is less risky than puncturing the middle or upper calyx. On the other hand, stone fragmentation can only be performed using flexible probes, limiting the lithotripsy options only to the electrohydraulic or laser methods.

6.3.1 Postoperative Follow-Up

In the second postoperative day, a reno-vesical radiography is advised to identify the possible residual lithiasic fragments (that would require maintaining the nephrostomy to repeat the procedure). In their absence, the nephrostomy tube can be clamped. If the patient tolerates this maneuver well, the tube may be extracted the following day. If a nephrostomy tube was not placed, the patient may be discharged on the second postoperative

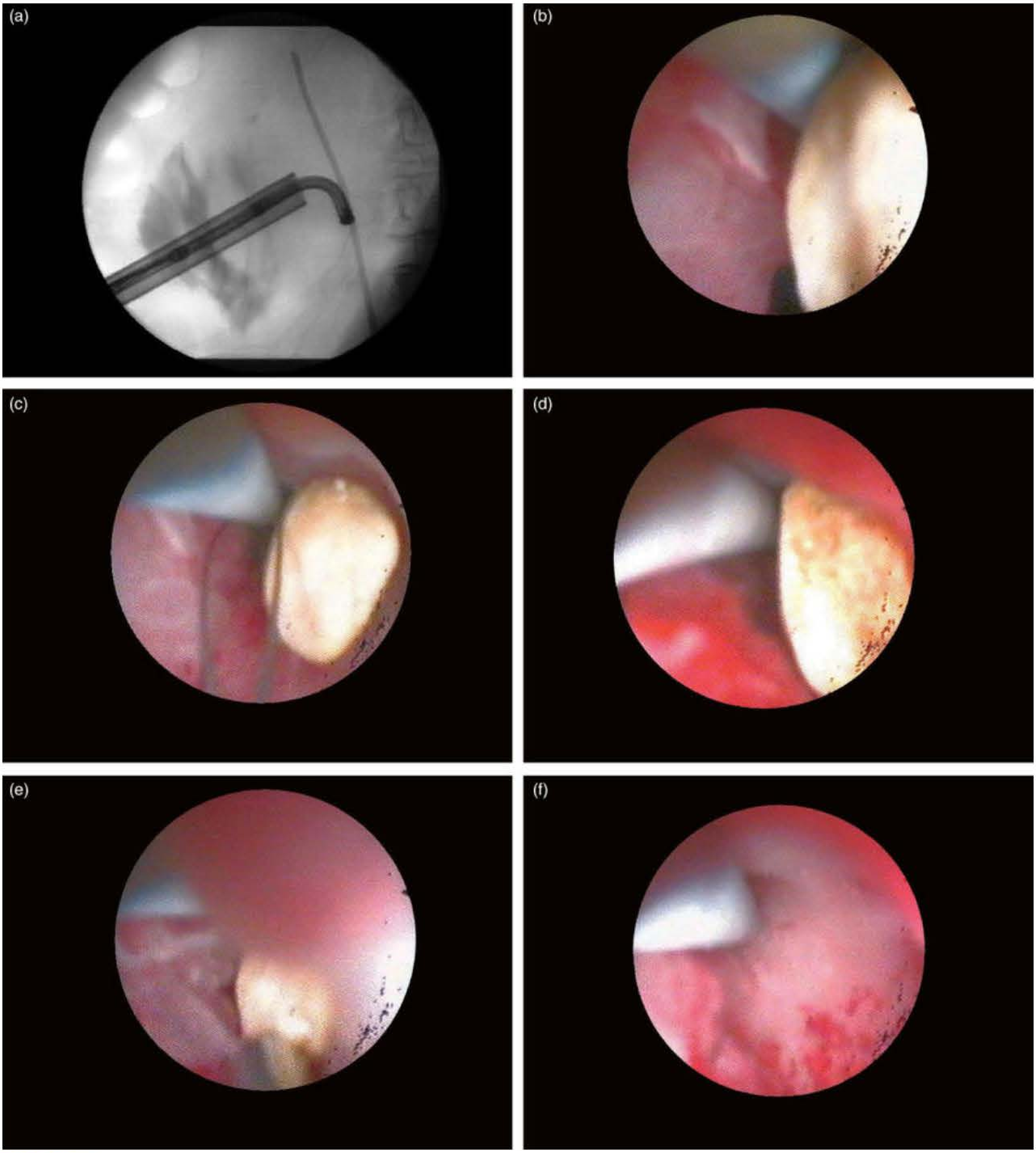

FIGURE 6.9 **Antegrade approach for a large lumbar ureteral stone.** Intraoperative fluoroscopy (a); stone identification (b); dislodging the stone using the basket catheter (c, d); stone fragmentation in the basket catheter (e); and final "stone-free" aspect (f).

day (Feng et al., 2001). In patients who required internal JJ catheter drainage, this can be extracted 7–14 days after the intervention.

Subsequent follow-up is performed 3 months after the procedure by renal ultrasonography, IVU, or computed tomography. In patients with large, impacted ureteral stones, the risk of developing a postoperative ureteral stricture

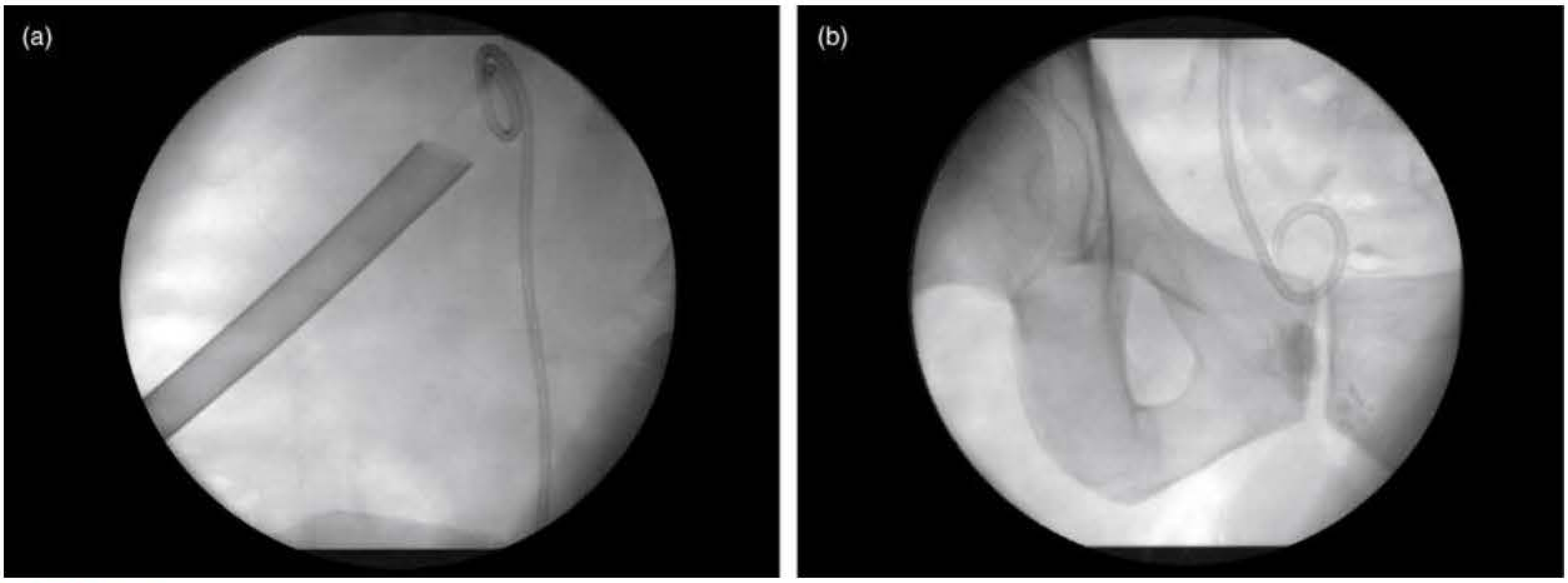

FIGURE 6.10 **Antegrade placement of a JJ catheter after antegrade ureteroscopy (a) and fluoroscopic control of its correct positioning (b).**

is relatively high, and therefore the postoperative follow-up is extremely important for the early diagnosis and treatment of this complication.

6.4 RESULTS

The "stone-free" rate after antegrade treatment of ureteral stones is approximately 88% after the first procedure, reaching almost 100% in the case of repeating the procedure (Table 6.2).

The localization of the stone in the distal ureter represents one of the factors for the failure of antegrade ureteroscopy. Thus, Reddy et al. (1985) observed the fact that all antegrade approaches which failed presented lower ureteral lithiasis.

TABLE 6.2 Summary of the Main Series of Patients Published in the Literature

Series	Number of patients	"Stone-free" after one procedure (after two procedures)	"Stone-free" rate after one procedure (after two procedures) (%)
Clayman et al. (1984)	44	4 (31)	9.8 (70)
Bush (1985)	37	30 (35)	81 (94)
Gumpinger et al. (1985)	22	22	100
Reddy et al. (1985)	68	65 (67)	98 (99)
Beckmann et al. (1986)	44	42 (44)	95 (100)
Kahn (1986)	60	57 (59)	95 (98)
Baba et al. (1987)	50	33 (50)	66 (100)
Streem et al. (1988)	29	25	83
Henriksson et al. (1989)	108	108	100
Anselmo et al. (1990)	17	16 (17)	94 (100)
Srivastava et al. (1992)	29	23 (27)	79 (93)
Kahn (1993)	9	9	100
Tan et al. (1995)	36	36	100
Kumar et al. (1996)	86	66 (83)	77 (97)
Toth et al. (2001)	51	50 (51)	98 (100)

Suprajacent ureteral dilation represents a favorable prognostic factor regarding the success rate of antegrade ureteroscopy. Thus, Streem et al. (1988) showed that the "stone-free" rate is higher in patients with ureteral lithiasis and suprajacent dilation (94%; 16/17 patients) compared to the cases without dilation (43%; 3/7 patients).

There are relatively few comparative studies in the literature regarding the effectiveness of antegrade versus retrograde ureteroscopic approach. Maheshwari et al. (1999) evaluated 43 patients with large, impacted proximal ureteral stones (larger than 1.5 cm), ureteroscopically approached. Of these, 20 were treated by retrograde ureteroscopy and 23 by antegrade approach. Associated lower caliceal stones were recorded in 4 patients from the first group and in 10 from the second group. The mean operating time was somewhat longer in the case of antegrade approach (90 min) compared to the retrograde approach (65 min), first because of the time required to achieve the percutaneous access tract. The stone-free rate was 100% for antegrade ureteroscopy and 55% for the retrograde one, including the secondary stones. In the nine cases with residual fragments, these were ascended into the pyelocaliceal system, extracorporeal lithotripsy being performed. Two patients in whom antegrade ureteroscopy was performed required transfusions. Similar results were obtained by Kahn (1993). However, these studies underestimated the value of the retrograde approach, not evaluating the role of flexible retrograde ureteroscopy.

6.5 COMPLICATIONS

The complications caused by antegrade treatment of ureteral stones are identical with those specific for the percutaneous approach of renal lithiasis. A reduction by 50% in the frequency of major complications was observed after 1990 compared to the previously published studies. This is probably due to the standardization of the operating technique and to the progress regarding the improvement of instruments.

The possible complications are relatively rare (Rudnick and Stoller, 1999) (Table 6.3).

The most frequent complication is fever, described with incidences of up to 28% (Troxel and Low, 2002). Important intra- or postoperative bleeding may require repeated blood transfusions.

Perforation of the renal pelvis or ureter, described in approximately 13% of cases in series published after 1990, represents another common complication. It can be detected endoscopically during the intervention or by contrast medium leakage, requiring internal JJ catheter drainage. In most patients the perforation heals without sequelae.

The risk of ureteral strictures is high in patients with impacted stones (approximately 24%).

Injuring the subcostal vessels (less than 2% of cases) and pulmonary complications (hydrothorax, pneumothorax: 5–10% of cases) are possible complications in the case of a supracostal approach (Gupta et al., 2002). They can usually be treated by simple aspiration or by placing a thoracostomy tube (Munver et al., 2001).

TABLE 6.3 Complications of Antegrade Ureteroscopic Approach

Series	Number of patients	Complications (%)	Complications
Clayman et al. (1984)	44	41	Bleeding, ureteral perforations, perirenal hematoma
Gumpinger et al. (1985)	22	4.5	Ureteral perforations
Kellett et al. (1985)	6	0	–
Beckmann et al. (1986)	44	2.2	Ureteral perforations
Kahn (1986)	60	10	Bleeding, ureteral perforations, ureteral avulsion, urosepsis
Baba et al. (1987)	50	8	Ureteral perforations
Streem et al. (1988)	29	0.5	Ureteral stenosis
Liong et al. (1989)	19	43	Ureteral perforations, pneumothorax, pneumonia
Anselmo et al. (1990)	17	5.9	Ureteral perforations
Berkhoff and Meijer (1990)	7	0	–
Srivastava et al. (1992)	29	13.8	Ureteral perforations, ureteral stenosis
Kahn (1993)	9	11.1	Bleeding
Kumar et al. (1996)	86	12.8	Ureteral perforations, bleeding, ureteral stenoses
Toth et al. (2001)	51	1.9	Retroperitoneal hematoma

Other complications, such as injury of the neighboring organs (colon, spleen, duodenum) (Goswami et al., 2001) or ureteral avulsion, occur with a lower incidence (under 1%).

However, despite all these possible complications, in selected cases the benefits of the antegrade approach are obvious: high "stone-free" rates after a single intervention, relatively low morbidity. Antegrade ureteroscopy may be recommended in cases in which the failure of the retrograde approach is anticipated, being an alternative to open surgical intervention.

Antegrade ureteroscopic approach is not a routine procedure for the treatment of urinary lithiasis, its indications being represented more by the contraindications of the first intention procedures for each case. Retrograde ureteroscopy, with its different technical options, is capable of resolving most ureteral or even intrarenal stones. Extracorporeal lithotripsy is gradually extending its indications also to ureteral stones, promising success rates of over 50% while being less invasive, if the failure of SWL does not represent a contraindication for the other treatment options.

In this context, antegrade ureteroscopy represents a more invasive alternative compared to retrograde ureteroscopy or SWL, and with a lower efficiency in many cases. The percutaneous puncture of the pyelocaliceal system and the dilation of the nephrostomy tract are the operative steps responsible for the high morbidity of this technique, but with the development of imagistics and of the instruments used, the safety profile of this procedure can increase, which will lead implicitly to a wider palette of indications for the procedures that imply this kind of approach.

For the moment, the antegrade ureteroscopic approach represents a technique with limited indications that offers good results for experienced surgeons and that can prove to be an indispensable instrument in cases in which conventional therapies cannot be provided or did not lead to a complete cure.

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CHAPTER

7

Percutaneous Approach of Upper Urinary Tract Tumors

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7.1 GENERALITIES

According to the 2012 European Association of Urology (EAU) guidelines, nephroureterectomy represents the gold standard treatment for urothelial carcinomas of the upper urinary tract. However, this is a complex surgical intervention associated with relatively high morbidity and mortality rates, especially in the age group most frequently affected by upper urinary tract transitional carcinomas. For this reason, in selected cases the endoscopic approach (antegrade or retrograde) may represent a viable alternative (Elliott et al., 1996; Martinez-Pineiro et al., 1996). Percutaneous treatment is generally used in cases of voluminous tumors which cannot be approached ureteroscopically (Jabbour et al., 2000).

Endoscopic techniques have recently been introduced in the management of urothelial tumors of the upper urinary tract. Huffman et al. (1985) reported the first case of a urothelial tumor treated by ureteroscopic resection. Shortly after, Streem and Pontes (1986) published the first case of a percutaneous approach for the treatment of a renal pelvic urothelial tumor. These techniques were later developed and popularized by Smith et al. (1987), who used local (topical) immunotherapy for the first time as adjuvant treatment after tumoral resection. Upper urinary tract urothelial tumors are rare, representing approximately 5% of all urothelial carcinomas (Munoz and Ellison, 2000). The vast majority are transitional carcinomas (90%), only 10% being squamous carcinomas and 1% adenocarcinomas (McDonald and Zincke, 1987). Urothelial tumors of the renal pelvis are three to four times more frequent than those localized at the ureteral level (Murphy et al., 1980).

The incidence of upper urinary tract transitional cell carcinoma (UUTTC) increases with age in both genders and reaches a maximum in the sixth and seventh decades of life. It is three times more frequent in men than in women (Bennington and Beckwith, 1975).

The predominant clinical manifestation of UUTTC is represented by hematuria. Patients with a history of recurrent superficial bladder tumors or radical cystectomy present an increased risk of developing upper urinary tract urothelial tumors and require surveillance. The imagistic diagnosis of UUTTC is based on intravenous urography (IVU) and contrast-enhanced computed tomography, which show filling defects at the level of the ureter or intrarenal tracts (Fig. 7.1).

Multidetector computed tomographic urography represents the modern gold standard for exploring patients with UUTTC, practically replacing intravenous urography (Van der Molen and Cowan, 2008). Positive urinary cytology associated with the imaging anomalies is suggestive for the diagnosis.

7.2 INDICATIONS AND CONTRAINDICATIONS

The ideal candidates for conservative percutaneous treatment are patients with low-grade UUTTC because they have a low risk of invasion and progression (Smith et al., 1987). Furthermore, superficial tumor relapses also tend to be superficial and can be resolved through local resection, as in the case of bladder tumors (Fig. 7.2).

Generally, these relapses, in time and space, are limited to the ipsilateral renal unit or the bladder (Fig. 7.3), the involvement of other segments of the genitourinary tract being described in 30–50% of patients (Oldbring et al., 1989). The localization of relapses at the level of the contralateral renal unit may appear in 1–5.8% of cases (Kang et al., 2003).

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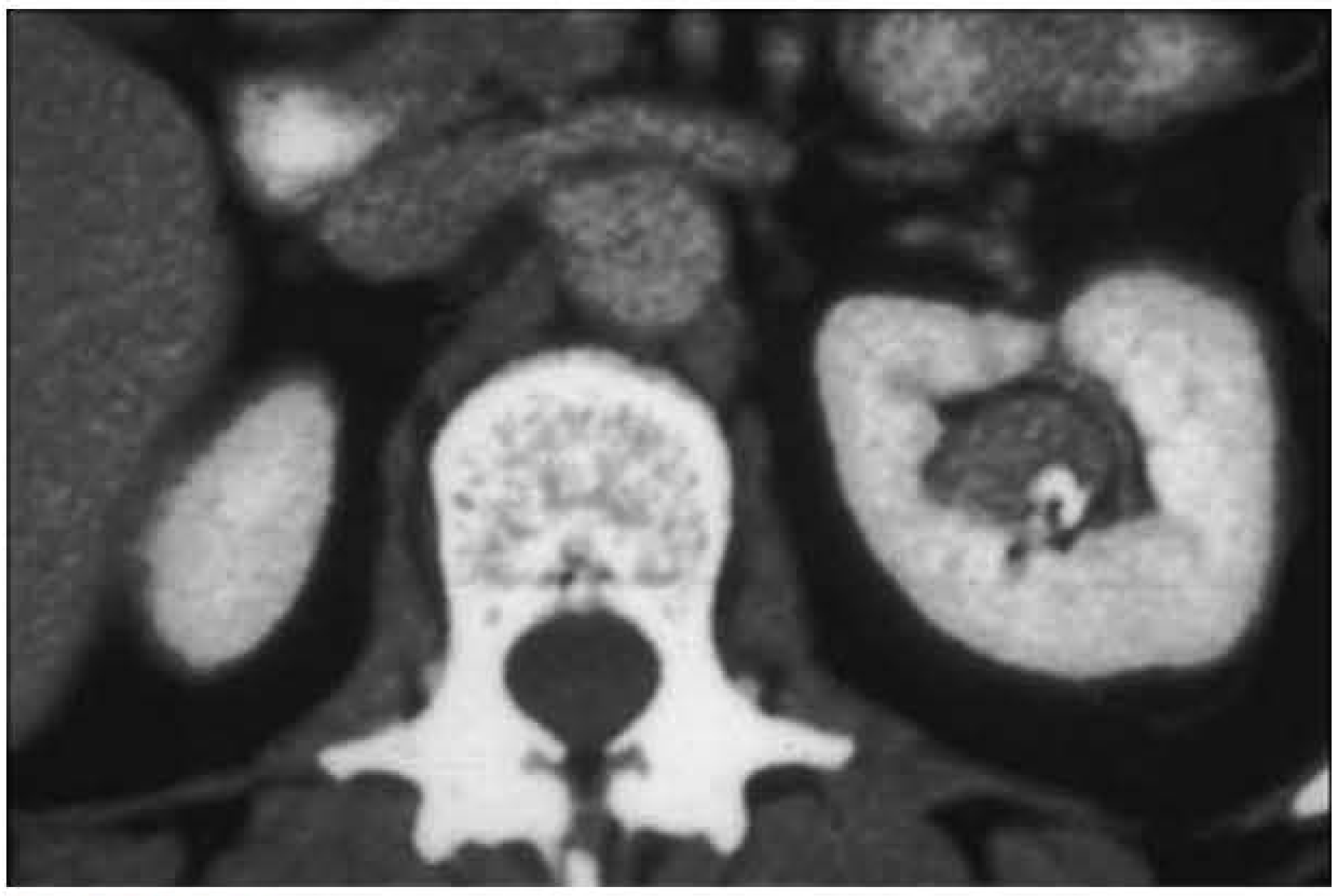

FIGURE 7.1 **Caliceal tumor.**

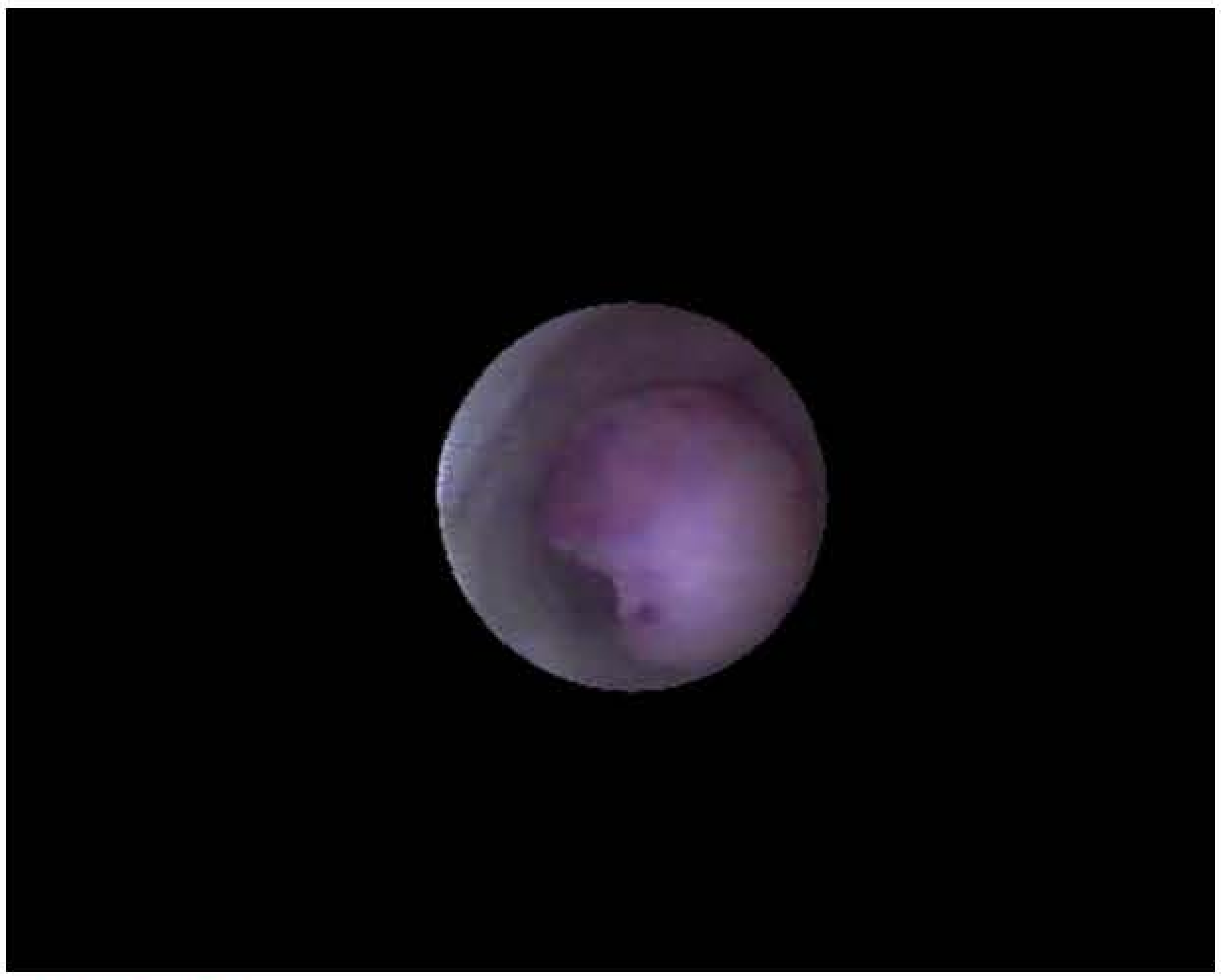

FIGURE 7.2 **Superficial ureteral tumoral relapse in a patient operated endoscopically for a renal pelvic tumor.**

The relapse and progression rates of urothelial carcinoma are directly correlated with the grade and the stage of the initially resected tumor. Stage I lesions have smaller relapse rates than grade 2 or 3 lesions. Thus, the Ta stage has a disease progression rate of 5%, much lower when compared to T1 (21%) and T2 (50%) tumors (Jabbour et al., 2000). Furthermore, the 5-year survival of patients with UUTTC is correlated with the tumoral grade and stage: 95% for *in situ* lesions, 89% for localized disease, 63% for tumors with local invasions, and 17% in the case of metastatic disease (Munoz and Ellison, 2000).

Initially, most authors recommended the endoscopic approach only when preserving renal function was required (bilateral tumors, solitary kidney, etc.). Recent progress, which has allowed for the significant improvement of diagnostic accuracy, has led to broader indications for conservative treatment which also include patients with low-grade tumors.

The modern indications for endoscopic conservative treatment may be summarized as follows (Kirkali and Tuzel, 2003; Zigeuner and Pummer, 2008):

- absolute or imperative indications – bilateral tumors (synchronous or metachronous), predisposition for multiple tumors (Balkan nephropathy), solitary kidney, kidney failure, associated comorbidities which contraindicate surgical treatment
- relative or elective indications – small, unifocal (with normal contralateral kidney), low-grade (or stage) tumors

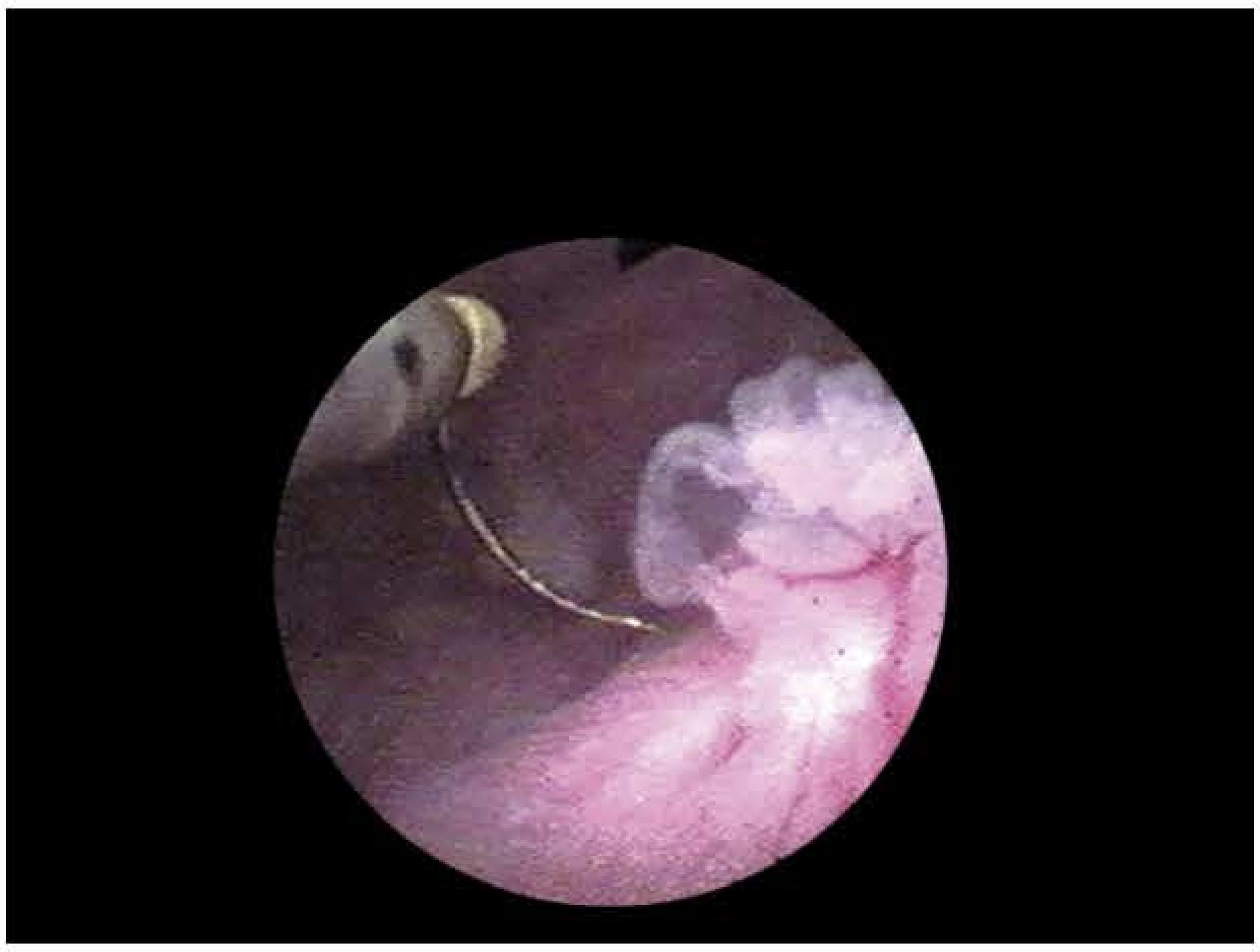

FIGURE 7.3 **Superficial bladder relapse in a patient with antegradely operated UUTTC.**

Regarding the elective indications, ureteroscopically obtained tumoral biopsy confers very accurate information on the tumoral grading (correlations of up to 90%) (Tavora et al., 2009), but without being very precise with regard to tumor staging (Daneshmand et al., 2003). Even so, several studies have shown a good correlation between tumoral grading and staging (Heney et al., 1981). Even though from an oncological point of view the risks are higher for conservatively treated patients, in selected cases survival is similar to that observed in patients undergoing nephroureterectomy. However, patients must be informed about the risk of tumoral relapse, requiring adequate surveillance.

Percutaneous approach is preferred in the case of large tumors located proximally at the level of the renal pelvis or lumbar ureter.

The main advantage of the percutaneous approach is the use of higher caliber endoscopes and a better visual control, as well as the possibility of resecting larger tumors (Jabbour et al., 2000). Biopsies obtained are deeper than those obtained through ureteroscopy, and the percutaneous approach may avoid the limits of flexible ureteroscopy, especially in the conditions of complicated caliceal systems or difficult to reach areas such as the lower calyces or upper urinary tract tumors in patients with urinary diversions. Both rigid and flexible nephroscopes can be used during the percutaneous approach, so that all caliceal groups can be inspected (Jarrett et al., 1995). Maintaining the nephrostomy tube after the procedure allows the subsequent administration of the topical adjuvant treatment.

The contraindications of the percutaneous approach are represented by poorly differentiated urothelial tumors (G3–G4), as well as by the invasive ones (especially in the case of a normal contralateral kidney). Also, tumors which, due to their localization, number, or size, cannot be completely resected have the indication for nephroureterectomy. The progression to a high tumoral grade or early tumoral relapse after endoscopic resection and adjuvant immunotherapy also represent contraindications of treatment by percutaneous approach (Goel et al., 2003).

The presence of urinary infection, arterial hypertension, bleeding diatheses, or coagulopathies requires delaying the endoscopic intervention until they are corrected. Morbid obesity does not represent a contraindication for the endoscopic approach, but ureteroscopy may be a more useful solution in these cases. Last but not least, noncompliant patients or those who cannot respect the postoperative follow-up protocol due to various reasons are not indicated for endoscopic treatment.

7.3 SURGICAL TECHNIQUE ELEMENTS

Most authors recommend the ureteroscopic approach in the case of small tumors that can be resected or vaporized by laser. In the case of large tumors that would require long operatory time or even multiple procedures for a complete treatment, the percutaneous approach is preferred (Jabbour et al., 2000). The main disadvantage of the antegrade approach is represented by the increased morbidity when compared to ureteroscopy. Creating the nephrostomy tract presents risks and potential inherent complications. Furthermore, the loss of urothelial integrity and the exposure of nonurothelial surfaces to tumoral cells present the risk of tumoral seeding along the nephrostomy tract (Huang et al., 1995).

The instruments necessary for the antegrade treatment of UUTTC include the equipment required for achieving imaging guidance (fluoroscope and/or ultrasonograph), accessory equipment (18 or 21G puncture needles, metallic guidewires, lumbotome), instruments for creating the puncture tract (fascial or coaxial metallic dilators, high-pressure dilation balloon), as well as those required for tumor ablation (rigid or flexible nephroscope, resectoscope, Ho:YAG or Nd:YAG laser).

The technique for creating the percutaneous tract is similar to the one described for percutaneous nephrolithotomy. Usually, subcostal access is preferred to avoid damaging the pleura. The approach through the middle or upper calyces is generally indicated for tumors of the renal pelvis. The direct caliceal approach is preferred for caliceal localizations. Additional percutaneous tracts are necessary in some cases for complete tumor resection (Jarrett et al., 1995; Jabbour et al., 2000; Deligne et al., 2002; Lee et al., 1999).

Inspection of the pyelocaliceal system using rigid or flexible instruments is performed after positioning the Amplatz sheath (Fig. 7.4).

After identifying the tumor, tumoral (if this was not done previously) and peritumoral biopsy samples are taken to assess the extension of the disease and to exclude a possible carcinoma *in situ*. Extemporaneous histological examination on ice is indicated. If the tumoral lesion has a high grade (grade 3), radical nephroureterectomy is recommended, due to its superior results compared to conservative treatment (Goel et al., 2003; Jabbour et al., 2000).

Biopsy can be performed both with the pinching forceps and with a resection loop from a standard resectoscope (especially in the case of tumors with a broad implantation base) (Fig. 7.5). To prevent migration of the resected fragments and to maintain optimal visibility, the removal of each sample taken is recommended.

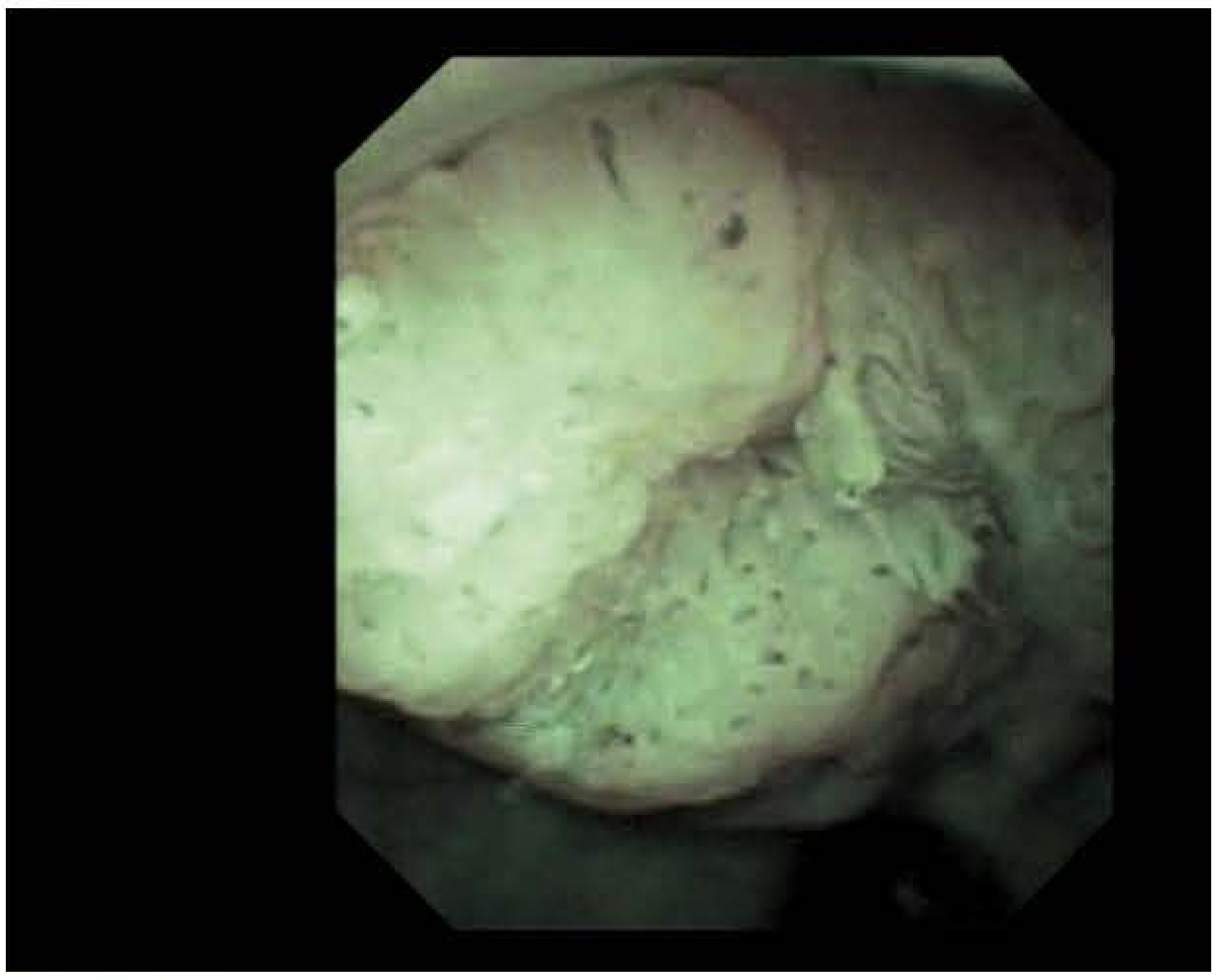

FIGURE 7.4 **Inspection of the pyelocaliceal system in a patient with a voluminous renal pelvic tumor.**

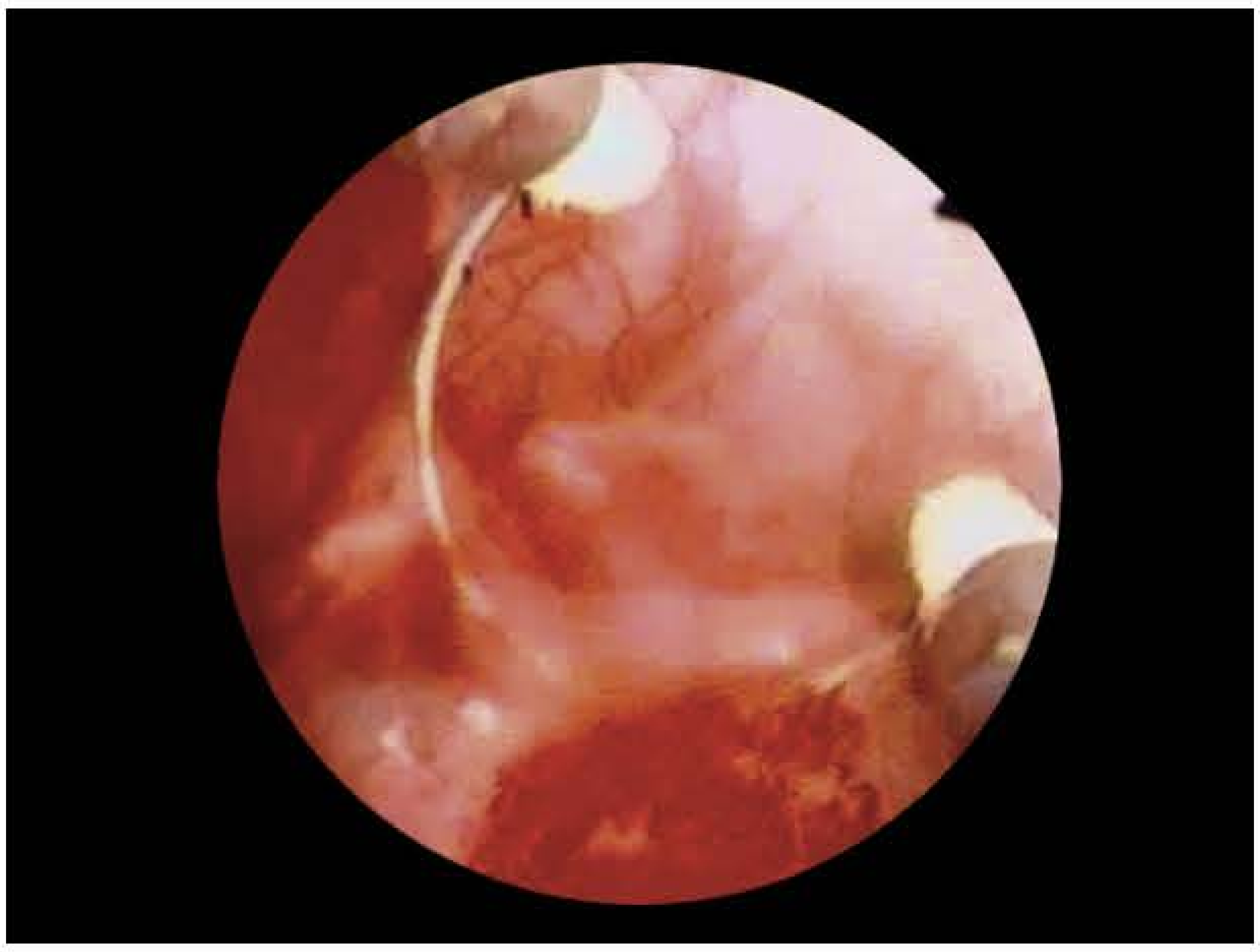

FIGURE 7.5 **Resection loop biopsy of a pelvic tumor.**

Also, to stage the disease as accurately as possible, separate biopsy of the tumoral base is recommended (Fig. 7.6), followed by its roller cauterization (Fig. 7.7). Furthermore, resection must be performed with great care so as not to resect too much in depth because the pyelocaliceal system does not have a thick muscular layer, a reason for which perforation with parenchymal or vessel damage is always possible.

Several alternatives for tumoral ablation have been described in the literature: monopolar or bipolar resection, electrovaporization, holmium:YAG (25 W), or neodymium:YAG (20 W) laser (Nakada and Clayman, 1995). Some authors recommend laser combinations (Daneshmand et al., 2003). The Nd:YAG laser can be used to coagulate most of the tumoral volume, having a greater penetrability (4–5 mm), while the Ho:YAG laser can be used for the tumoral base (due to its superficial penetrability) (Mills et al., 2001). The adequate power control and the fact that the thermal effect on adjacent tissues diminishes with distance make laser energy safe for the ureteral wall or renal pelvis, which are very thin. Actually, the reduced perforation risk and the absence of bleeding lead to the decrease in the risk of ureteral stenosis and tumoral cell extravasation.

After removing the tumor, an inspection with flexible instruments is recommended, eventually using narrow band imaging (NBI) to exclude the existence of associated tumors (Fig. 7.8).

At the end of the intervention, a nephrostomy tube (24–26 Ch) is positioned, which can be used for a second-look nephroscopy 4–7 days after the procedure (Liatsikos et al., 2001; Jabbour et al., 2000). This is useful for removing any residual tumor. If no residual tumors are identified, the tumoral base must be biopsied and treated using the electrocauter or Nd:YAG laser (15–20 W). Some authors suggest performing a third control nephroscopy (third look) with random biopsies before the nephrostomy tube is suppressed (Nakada and Clayman, 1995). For topical adjuvant treatment, it is necessary to leave an 8 F nephrostomy tube in place.

7.3.1 Adjuvant Therapy

Similar to bladder tumors, adjuvant treatment after the percutaneous resection of urothelial tumors has been used with the purpose of reducing the incidence of tumoral relapses. Immunotherapy or chemotherapy may be used. The first reported use of bacillus Calmette–Guerin (BCG) at the level of the upper urinary tract belongs to Herr (1985).

BCG is usually administered in six weekly instillations through the nephrostomy tube, the first dose being administered 2 weeks after the second-look nephroscopy (to reduce the risk of BCG systemic infection) (Thalmann et al., 2002). The therapeutic protocol requires negative uroculture, the absence of hematuria, and the absence of any urinary obstruction. Fifty cm^3 of 1×10^8 BCG colony forming units (or one vial diluted in 50 cm^3 of saline solution) are administered through the nephrostomy tube. The instillation is performed gravitationally, from 20 cm above the patient placed in dorsal decubitus, over a period of 2 h. After instillation, the tube is clamped for 1 h. Two weeks after finishing the BCG instillations, a control nephroscopy (third look) can be performed (Goel et al., 2003).

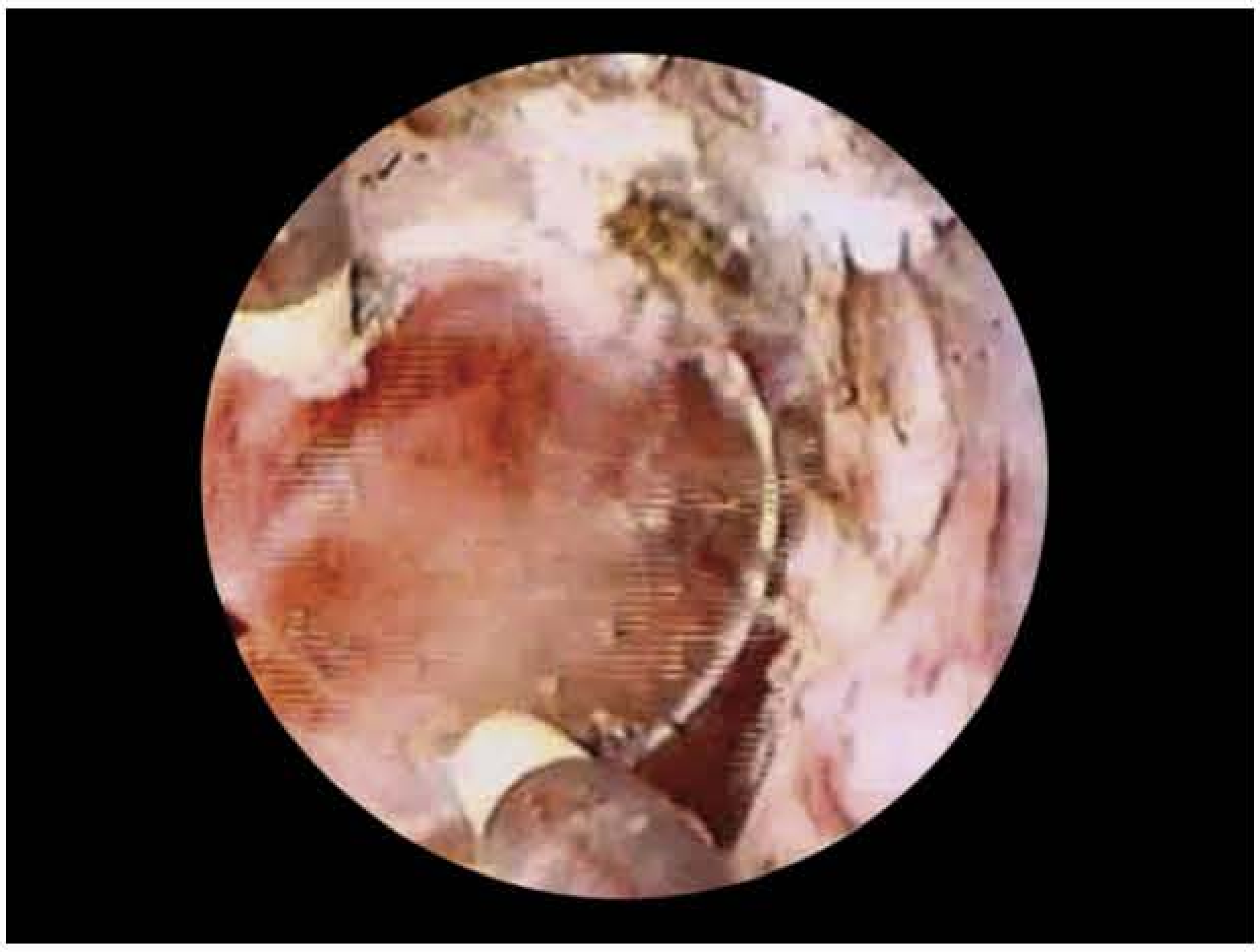

FIGURE 7.6 **Biopsy of the tumoral base.**

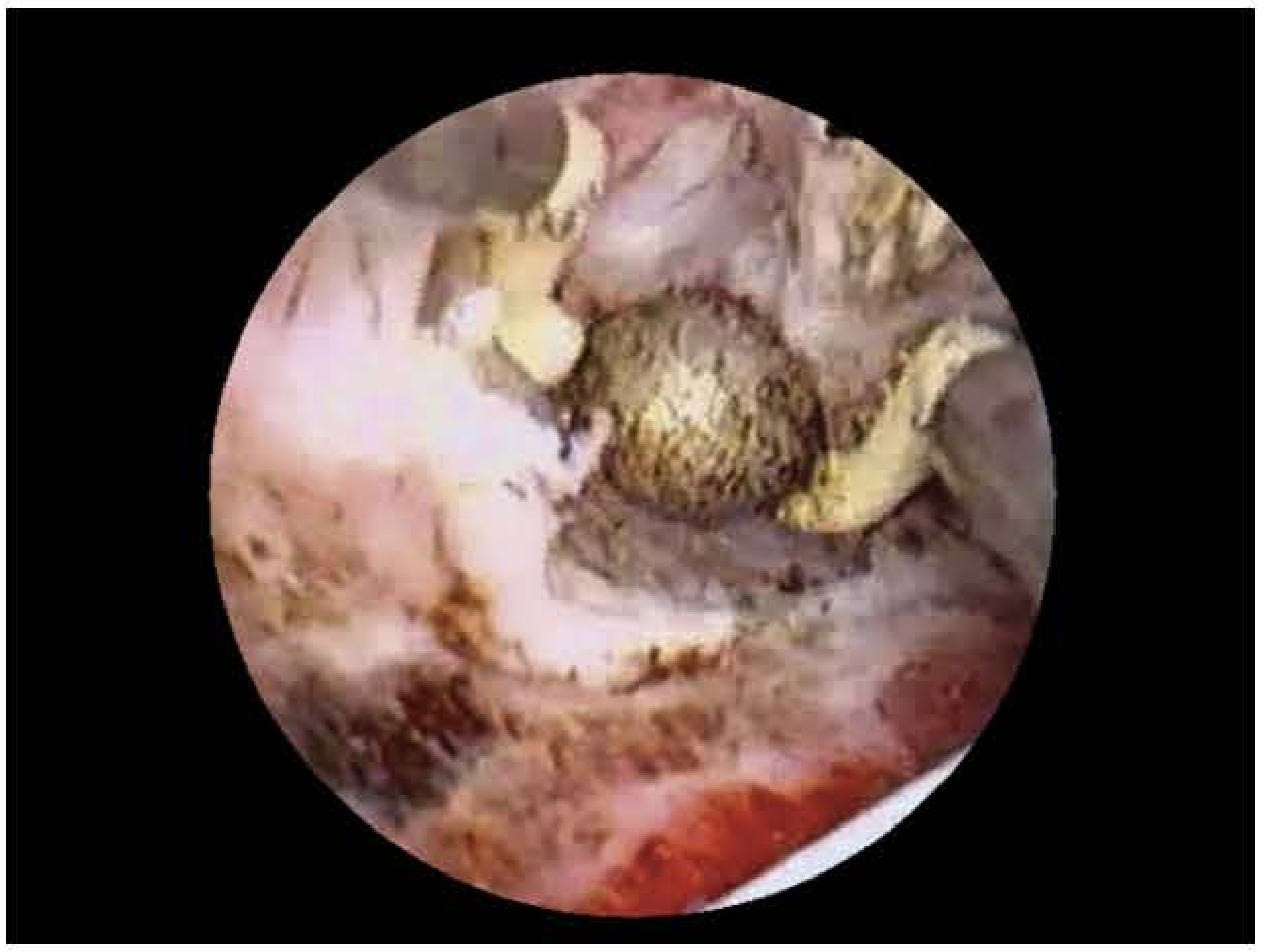

FIGURE 7.7 **Roller cauterization of the tumoral base.**

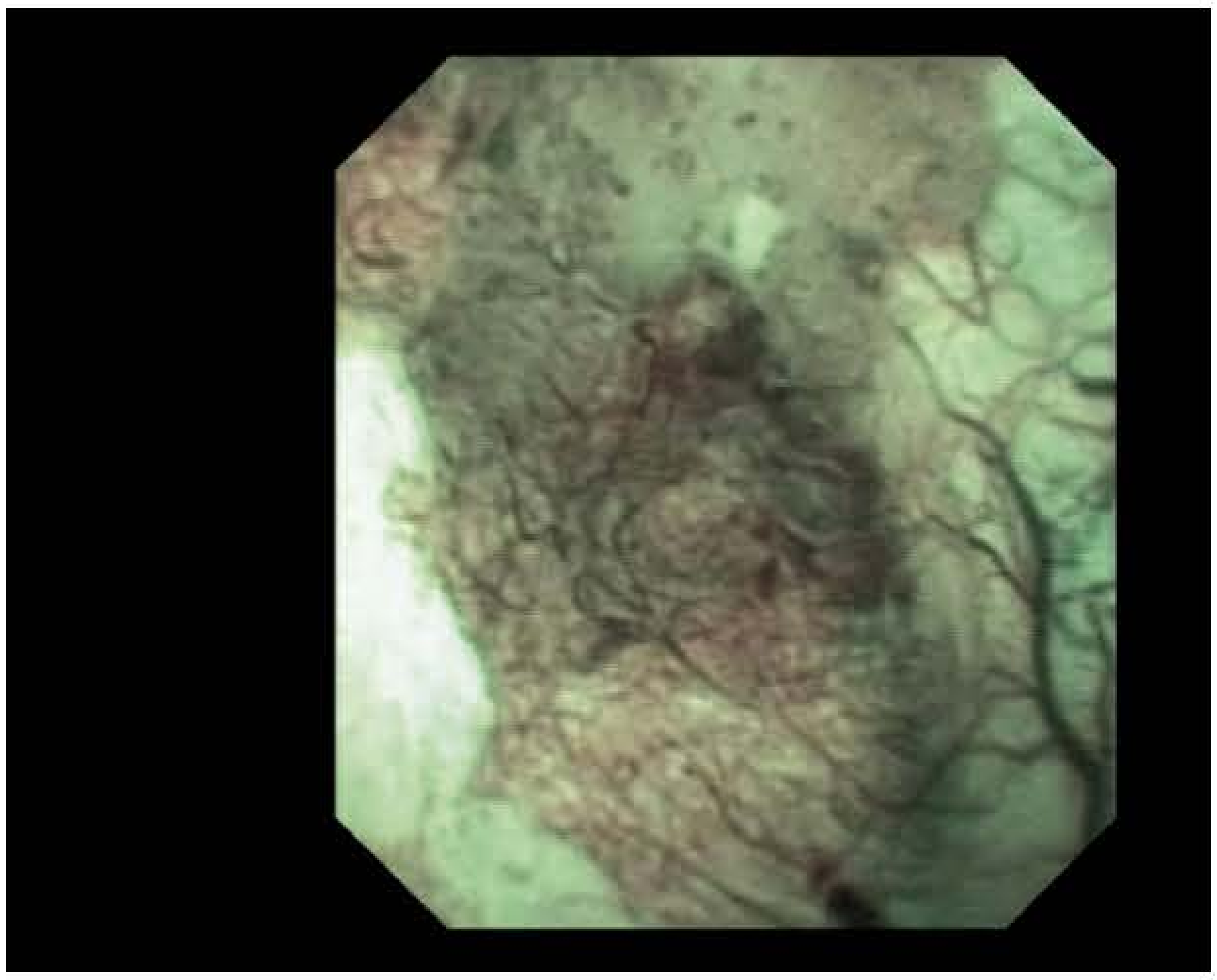

FIGURE 7.8 **Associated caliceal tumor objectified in NBI.**

Bladder instillations in the Trendelenburg position after positioning a JJ stent can be used as an alternative (Jabbour et al., 2000). Nevertheless, the duration of urothelial exposure is variable and for this reason the efficiency of these methods is doubtful.

Adriamycin (See, 2000) and mitomycin (Nakada and Clayman, 1995; Blute, 1996) (20 mg in 50 mL of water) are the chemotherapeutic agents most often used as adjuvant therapy. BCG and mitomycin C adjuvant treatment are the most studied and these agents are considered as having the best results in reducing the recurrence rate of upper urinary tract urothelial carcinomas. Martinez-Pineiro et al. (1996) described a relapse rate of 12.5% in patients treated with BCG and 14.2% in those treated with mitomycin C, compared to 60% for thiotepa and 40% for patients treated orally with 5-fluorouracyl.

7.4 POSTOPERATIVE FOLLOW-UP PROTOCOL

A rigorous follow-up of patients represents an essential element in the percutaneous management of urothelial tumors.

Patients are reevaluated once every 3 months during the first year, once every 6 months in the following 4 years, and then yearly. Reevaluation always includes patient history, physical exam, and urinary cytology. Cystoscopy is also required due to the increased incidence of bladder tumoral relapse in these patients. The occurrence of symptoms such as flank pain or macroscopic hematuria requires additional investigations.

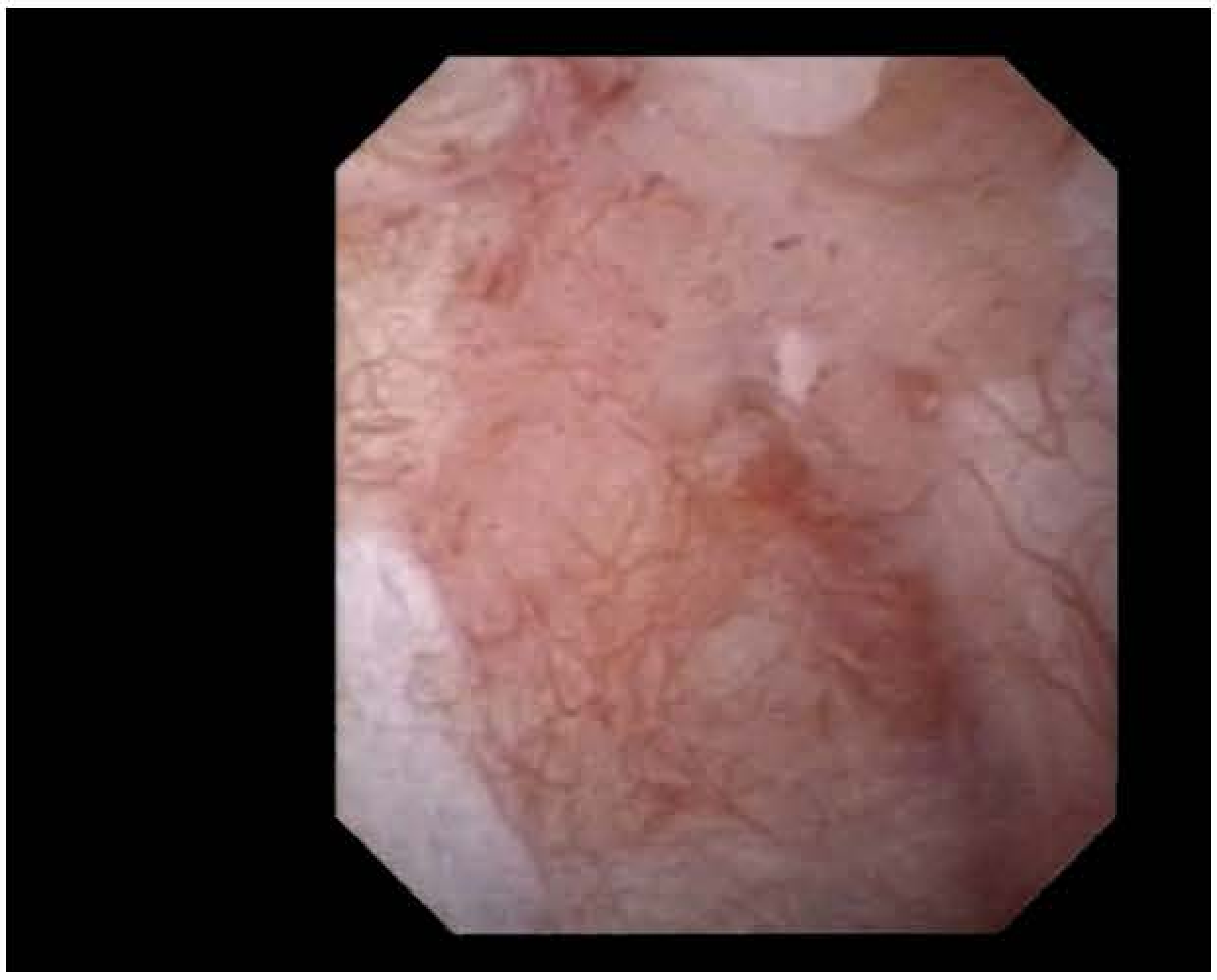

FIGURE 7.9 **Ureteroscopically objectified caliceal relapse.**

The assessment of the entire upper urinary tract through IVU or retrograde ureteropyelography is indicated at 3–6-month intervals. Using intravenous urography as the only follow-up method does not guarantee the identification of tumoral relapses (Goel et al., 2003). Also, retrograde pyelography has a sensitivity which varies between 0% and 72% regarding the diagnosis of relapses (Okubo et al., 2001; Chen et al., 2000).

Urinary cytology has a reduced sensitivity, 18% of patients with negative cytology having tumoral relapse (Kawakami, 2002).

Ureteroscopy has replaced IVU (Fig. 7.9) due to its higher sensitivity in tumor detection (Keeley et al., 1997; Goel et al., 2003). Because ureteroscopy is an invasive procedure, it can be performed yearly or when required by the clinical context. Poorly differentiated lesions must be monitored with greater attention and the assessment must also include the detection of potential metastases.

If a progression of adenopathies or an intrarenal residual tumor is detected, immediate nephroureterectomy is required in most cases (Goel et al., 2003).

When is the conversion to nephroureterectomy done? Goel et al. (2003) showed that after 5 years of follow-up, percutaneous resection allows the preservation of the renal units in 60% of patients with low-grade lesions. Immediate nephroureterectomy is indicated in patients with aggressive lesions.

7.5 RESULTS

Conservative management of upper urinary tract urothelial tumors requires careful monitoring for detecting relapses at the level of the primary tumor or at another level of the upper urinary tract. Bladder relapses occur in 30–50% of patients (Oldbring et al., 1989; Kang et al., 2003) and therefore control cystoscopy is necessary.

The first representative series of solitary kidney UUTTC treated percutaneously was published by Smith et al. (1987). The long-term results published in the literature are variable due to the diversity of patients' characteristics, follow-up protocols, and the relatively small number of patients.

Comparative studies have reduced applicability due to the nonhomogeneous inclusion criteria. When these results are compared to the results of nephroureterectomy, one must take into account the possibility of understaging conservatively treated patients, since histological staging is not available in all cases.

Table 7.1 highlights the main series of patients with percutaneously treated UUTTC published in the literature.

The recurrence rates are directly proportional with the tumor grade, low-grade tumors having a lower relapse rate (18–28%) compared to high-grade ones (50%). One fact constantly demonstrated by studies is that tumor grading is the most important prognostic factor for the occurrence of relapses and cancer-specific mortality. Tumor relapse rates increase with the tumor grading: 18–28% for low-grade tumors, respectively, 50% for high-grade ones (Jarrett et al., 1995; Clark et al., 1999). Similarly, the time until the occurrence of relapses depends on tumor grading, poorly differentiated tumors relapsing faster than well-differentiated ones.

TABLE 7.1 Summary of the Results of Percutaneous Treatment of UUTTC

Series	No. of patients	No. of pTa/pT1	No. of G1/G2/G3	Adjuvant treatment	Follow-up period (months)	No. of patients requiring salvage NU	Deaths through disease	Relapse
Goel et al. (2003)	20	20	G1, 2–15, G3–5	10 Mitomycin C or epirubicin	64	6 (Low-grade) 4 (Low-grade)	4 (All G3)	30% (6/20)
Deligne et al. (2002)	61	48 (8 Benign)	21/22/5	37 BCG	39.9	6	8/61 (13%)	36% (22/61)
Clark et al. (1999)	17	52	15/21/22	BCG	20.5	0	6/17 (35.3%)	33%
Jabbour and Smith (2000)	54 Perc, 6 URS	52	15/21/22	30 BCG	59	4	NU	8.3% (5/60)
Jabbour et al. (2000)	20	20	20 G2	BCG	48	1	0	25% (5/20)
Martinez-Pineiro et al. (1996)	39 URS, 18 perc, 2 combined	48	24/18, 10	BCG, mitomycin C, thiotepa or 5-FU	30.7	6/39 URS, 3/18 perc, 10 immediate NU	4.59 (6.8%)	35% (8/23) URS, 11 (2/19) perc
Lee et al. (1999)	50 Perc, 60 open NU		Perc: 20/16/13; open: 6/30/13	BCG	46.6	1	4/50 (8%)	12% (6/50) Perc, 18% (11/60) open NU
Patel et al. (1996)	26	18	11/11/1	Tract brachytherapy	44–60	2	2/26 (7.7%)	23% (6/26)
Jarrett et al. (1995)	30	NU	11/9/10	BCG	55	9/30	6/30 (20%) All G3	33% (10/30) 18% Relapse G1 up to 50% pt. G3

Perc, treated percutaneously; NU, nephroureterectomy.

G1 tumors generally have a good prognosis. The recurrence rates after percutaneous approach are relatively low and comparable to those reported for nephroureterectomy. Many authors have reported very good results for grade 1 tumors, with 0–29% recurrence rates and a disease-specific survival of 100% (Keeley et al., 1997; Jarrett et al., 1995; Fulgsig and Kraup, 1995; Plancke et al., 1995; Lee et al., 1999; Patel et al., 1996).

With regard to G2 tumors, there are studies (Lee et al., 1999) which have demonstrated that there are no differences regarding disease-specific survival between open surgery and percutaneous approach (53.8 compared to 53.3 months; $p > 0.05$). These data prove the fact that high-grade lesions have a higher relapse rate regardless of the treatment method applied (25% and 31% for grade 3 tumors treated by open surgery and percutaneous approach, compared to 14% and 6% for grade 1/2 tumors treated by open surgery and percutaneous approach). Generally, the progression rate of G2 tumors does not exceed 11% (Murphy et al., 1981). The disease-specific survival rate ranges between 8% and 100%. TaG2 tumors have a 6–20% progression rate, while T1G2 tumors have a 21–40% progression rate (Fulgsig and Kraup, 1995; Heney, 1992; Jabbour et al., 2000).

The prognosis is poor in the case of G3 tumors, regardless of the chosen treatment. The 5-year disease-specific survival rate is 60%, with a relapse rate of over 50% (Jabbour et al., 2000). Immediate nephroureterectomy is indicated in these cases.

Most authors do not describe significant differences between the various types of energy used, the success rates being comparable regardless of the use of laser or electroresection (Elliott et al., 1996; Schoenberg et al., 1991). However, there are studies that objectify a better local tumoral control by using resection (Martinez-Pineiro et al., 1996).

From the global analysis of the results, it can be concluded that high-grade lesions have a poor prognosis regardless of the therapeutic option. In contrast, in patients with low-grade, well-differentiated tumors, the percutaneous approach represents a viable option, with the condition that the patient is compliant with regard to the postoperative follow-up. The most controversial cases regarding the therapeutic indication are those with G2 tumors and normal contralateral renal unit.

7.6 COMPLICATIONS

Unlike the retrograde approach of UUTTC, the antegrade one is associated with a higher complication rate, most being similar to those described for the percutaneous approach for other benign conditions:

- cutaneous urinary fistula
- hydrothorax or hemothorax (Patel et al., 1996): it is recommended to avoid intercostal punctures
- injury of the parenchymal or cavitary organs (Clark et al., 1999)

Usually, the percutaneous approach is used for relatively large tumors which frequently require an extensive resection, with inherent risks of bleeding. In fact, this represents the most frequent complication described in the literature (Jarrett et al., 1995). Thus, the need for postoperative transfusion may occur in over 50% of cases, approximately 10% requiring subsequent embolization. Necessity of nephroureterectomy has been described in 5% of cases.

Secondary strictures following resection of tumors located in the vicinity of the pyeloureteral junction represent late complications, which can be reduced by avoiding circumferential resections or by using the laser.

The risk of seeding along the percutaneous approach tract was first suggested by Tomera et al. (1982). Even so, there are few studies that confirm this risk (Huang et al., 1995), suggesting that tumoral seeding of the tract actually occurs very rarely in medical practice. Various methods for reducing this risk have been cited: maintaining a low intraoperative pressure of the irrigation fluid, irradiating the tract (Shepherd et al., 1995), or using sterile water as irrigation fluid due to its cytolitic effect (Carson, 1991).

As in the case of adjuvant treatment for bladder tumors, BCG can be associated with intravesical and systemic complications. Renal tuberculomas have been described after BCG instillations into the upper urinary tract (Hayashida et al., 2004). Some authors recommend the routine use of isoniazid during BCG therapy to reduce this adverse effect (Kawakami, 2002). Patients must be monitored for signs and symptoms of BCG sepsis (joint pains, muscle pains, fever, cystitis, hepatitis), for which the treatment is identical to the one following intravesical BCG instillations (Bellman et al., 1994; Paterson and Patel, 1998).

BCG instillations do not seem to deteriorate the renal function, although there have been reported cases of exacerbation of chronic renal failure due to BCG. Toxic agranulocytosis secondary to the absorption of mytomicin C has been reported extremely rarely (Martinez-Pineiro et al., 1996).

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CHAPTER

8

Percutaneous Nephrostomy

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Percutaneous nephrostomy is a minimally invasive method for the external drainage of the upper urinary tracts, performed under ultrasonographic or fluoroscopic guidance. The purpose of the method is, first, to decrease the pressure and distension of the pyelocaliceal system, together with gaining an antegrade access to the upper urinary tract to perform different diagnostic and therapeutic procedures (Dondelinger, 1990).

The antegrade pyelogram, first performed in 1954 by Wickbom by percutaneous puncture of the renal pelvis, was the starting point for the development of this procedure. The first description of the percutaneous renal approach was made by Goodwin et al. (1955), who performed a pyelostomy by percutaneous puncture of an extrarenal pelvis in a pregnant woman with hydronephrosis. In Romania, the first percutaneous renal intervention was performed in Tîrgu Mureş in 1985 by Professor Radu Boja.

8.1 INDICATIONS

At its beginnings, percutaneous nephrostomy was almost exclusively used for the temporary drainage of the obstructed renal unit. Subsequently its indications were extended, being used both for diagnostic and, in most cases, for therapeutic purposes (Dyer et al., 2002).

Thus, nephrostomy is indicated for obtaining a urinary diversion in the case of upper urinary tract obstruction (neoplasia, lithiasis, benign conditions) or for the management of perforations or fistulas. For nephrolithiasis, nephrostomy can be used in the case of symptomatic lithiasic disease (pain, bleeding, associated infections) for decompressing the obstructed renal unit, as an adjuvant method for extracorporeal lithotripsy, or as primary treatment of recurrent lithiasis in the context of a metabolic disease.

Complex infections of the upper urinary tract may require emergency percutaneous nephrostomy with drainage of the renal unit to prevent the onset of sepsis.

Another indication is represented by interventions on the ureter that may require creating a suprajacent urinary diversion.

Also, the antegrade nephroscopic or ureteroscopic approach requires creating a nephrostomy tract, through which specific instruments are inserted.

8.2 CONTRAINDICATIONS

Percutaneous nephrostomy can be contraindicated in the context of associated diseases, due to the high risk that they involve (Ramchandani et al., 2003; Scârneciu et al., 2006):

- uncorrected severe coagulopathies
- anticoagulant therapy
- uncontrolled arterial hypertension
- hyperkalemia above 7 mEq./L (requiring prior correction through dialysis)
- terminal diseases

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8.3 INSTRUMENTS

The following instruments are commonly used to achieve a percutaneous nephrostomy:

- puncture needle (18–22 gauge)
- Teflon fascial dilators
- reinforced nephrostomy metallic guidewires
- different caliber mono J catheters or Foley catheters
- collecting bags

8.4 PREOPERATIVE PREPARATION

The intervention does not require a special preoperative diet or preoperative bowel preparation. The preoperative evaluation includes common biological tests (complete blood count, bleeding times and coagulation, creatinine, acid–base balance, and urine culture). Also, imaging investigations are necessary to highlight the patient's anatomic details (ultrasound, computed tomography, or intravenous urography).

Depending on the pathology specific for each case, a nephrology, oncology, gynecology, or general surgery consultation may be required.

Due to the risk of infection, in most cases the intervention being performed on an obstructed and/or infected renal unit, prophylactic antibiotic treatment is recommended.

8.5 STEPS OF THE INTERVENTION

Nephrostomy is generally carried out under local anesthesia, but sometimes general anesthesia is also used.

The patient is placed on the operating table in the prone position, the approach of the kidney being performed in the lumbar area, posterior, to avoid injury of the abdominal viscera. Detailed knowledge of the position and relations of the kidney, of the anatomy of the pyelocaliceal system, and of the spatial orientation represents a major desideratum to achieve a percutaneous nephrostomy.

Similar to percutaneous nephrolithotomy (PCNL), other positions can also be adopted for nephrostomy (supine, lateral, etc.), the choice being dictated by the case's characteristics and by the surgeon's preference.

The patient will be draped with sterile fields and the puncture site will be disinfected (most commonly with betadine solution).

The nephrostomy tube is placed under fluoroscopic or ultrasonographic guidance, rarely requiring computed tomography.

Ultrasonography is preferred because it avoids the irradiation determined by the use of fluoroscopy.

Puncture under ultrasonographic guidance is usually performed using a 3.5-MHz convex transducer, with a focus of 7–9 cm. For children it is recommended to use a 5-MHz linear transducer, with a focus of 5–7 cm.

Visualizing the puncture needle is essential for the success of the procedure (Fig. 8.1). This is facilitated by the use of a mechanical system for attaching the puncture needle to the transducer, with the virtual trajectory of the needle displayed on the monitor.

In the case of performing a nephrostomy without a guidance system, the procedure begins with the assessment of the kidney and the choice of the puncture site, with the needle's progression monitored ultrasonographically from another plane. This method has the disadvantage that the puncture's depth cannot be evaluated and that the planes that are crossed by the needle cannot be highlighted in real time. Consequently, the risk of injuring the abdominal viscera is higher compared to the technique where the needle is attached to the transducer.

For ultrasound-guided punctures, 18G needles are preferred because they have a higher rigidity and can be better visualized by ultrasound.

The characteristics of an ideal puncture are represented by a tract that is as short as possible and that crosses the skin, the renal cortex, up to the caliceal cup.

In the case of fluoroscopic guidance, the procedure begins with the retrograde opacification of the pyelocaliceal system (Fig. 8.2), with the patient placed initially in the lithotomy position.

A posterior calyx will always be punctured, most of the time from the lower group (Fig. 8.3). Depending on the case's particularities, calyces of the middle (Fig. 8.4) or upper group can also be punctured. The puncture is

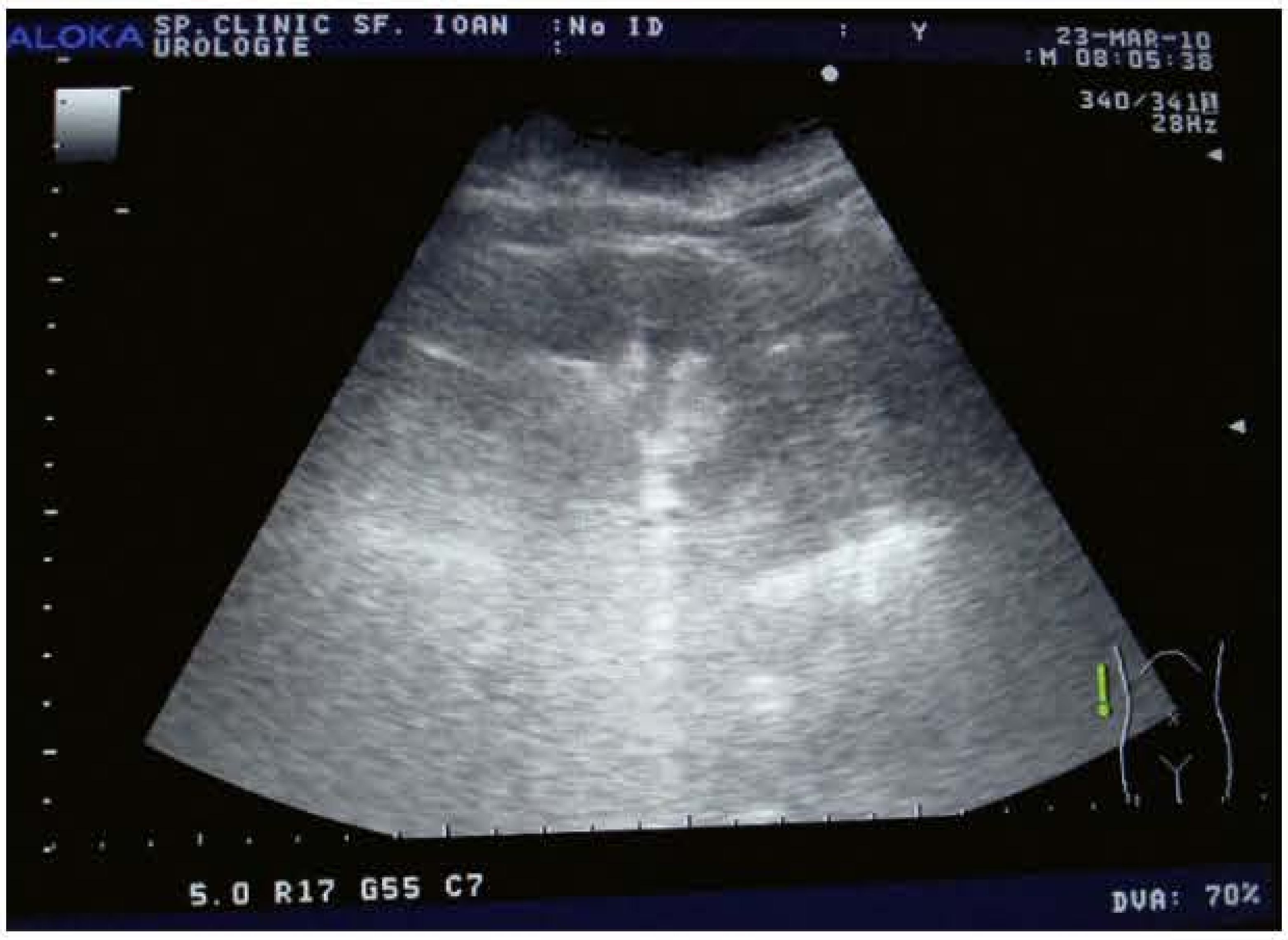

FIGURE 8.1 **Ultrasound-guided puncture of the pyelocaliceal system.**

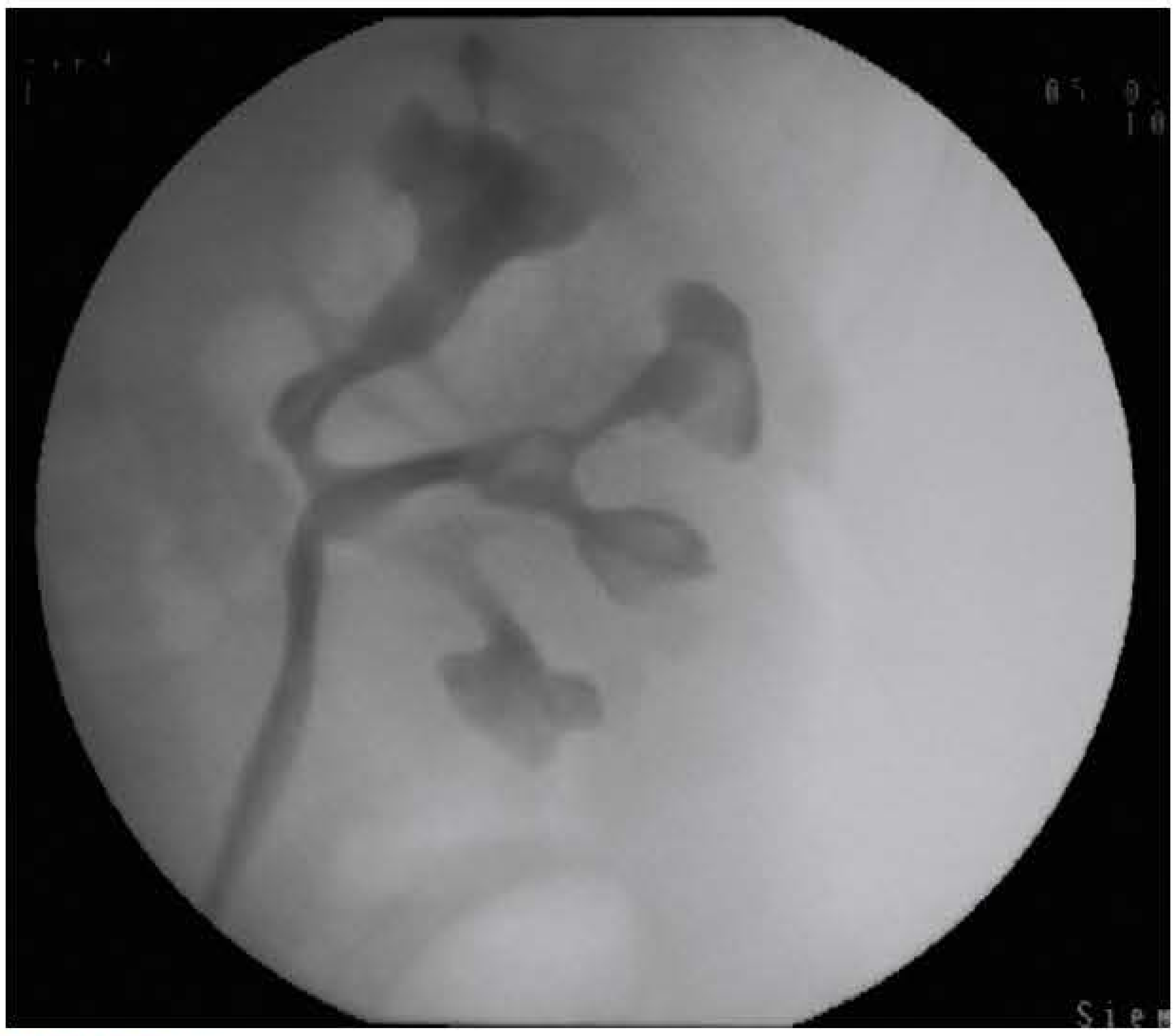

FIGURE 8.2 **Retrograde PCS opacification (fluoroscopic aspect).**

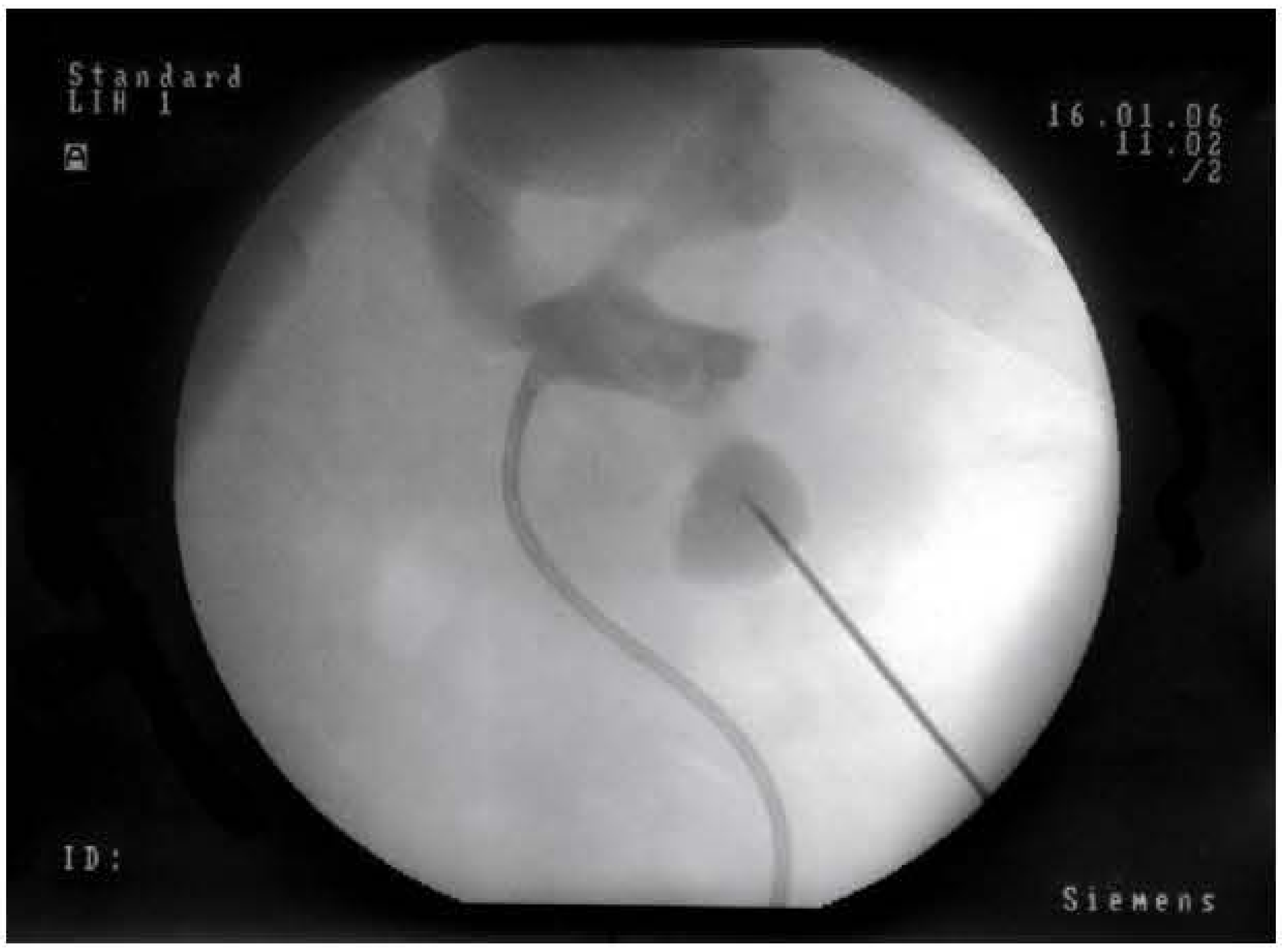

FIGURE 8.3 **Puncture of the lower caliceal group (fluoroscopic aspect).**

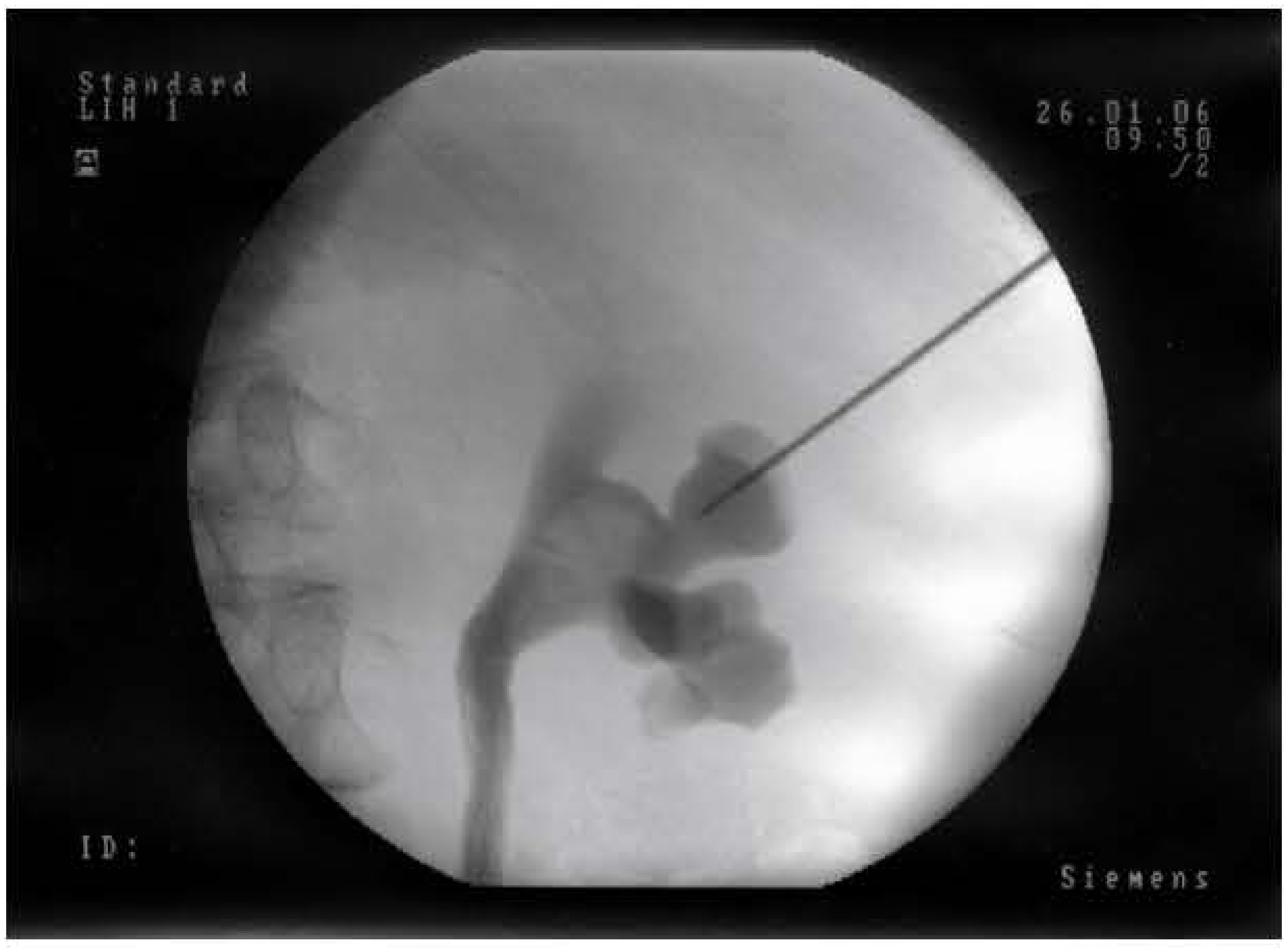

FIGURE 8.4 **Puncture of the middle caliceal group (fluoroscopic aspect).**

performed on the posterior axillary line, at a 20–30° oblique-posterior angle to avoid the large vessels (renal artery or vein), preferably below the XII-th rib. The puncture needle's mandrel is then extracted, the presence of the needle in the pyelocaliceal system confirmed by urine leakage through the needle. Then, 3–5 mL of contrast agent will be injected for opacifying the pyelocaliceal system, to confirm the correct position of the needle.

The guidewire (0.035–0.038 in.) is then inserted; it must be placed in the renal pelvis or on the ureter, and the puncture needle is carefully extracted. A small scalpel incision will be made to section the lumbodorsal fascia. The puncture tract will be dilated using the fascial dilators (6 F, 8 F, and 10 F) placed on the guidewire (Boja, 2006). Specific dilators (Alken, Amplatz-type) will be used in the case of PCNL.

The next step is to place a nephrostomy tube (8–14 F, depending on its purpose) in a correct position, attached to the skin with nonabsorbable threads. A urine collecting bag will be attached to the tube. The guidewire can be extracted only after the catheter's position is verified fluoroscopically.

If there are urine leaks along the nephrostomy tube, this can be replaced subsequently with a larger caliber tube. An additional suture thread can be added in case of bleeding from the parietal wound.

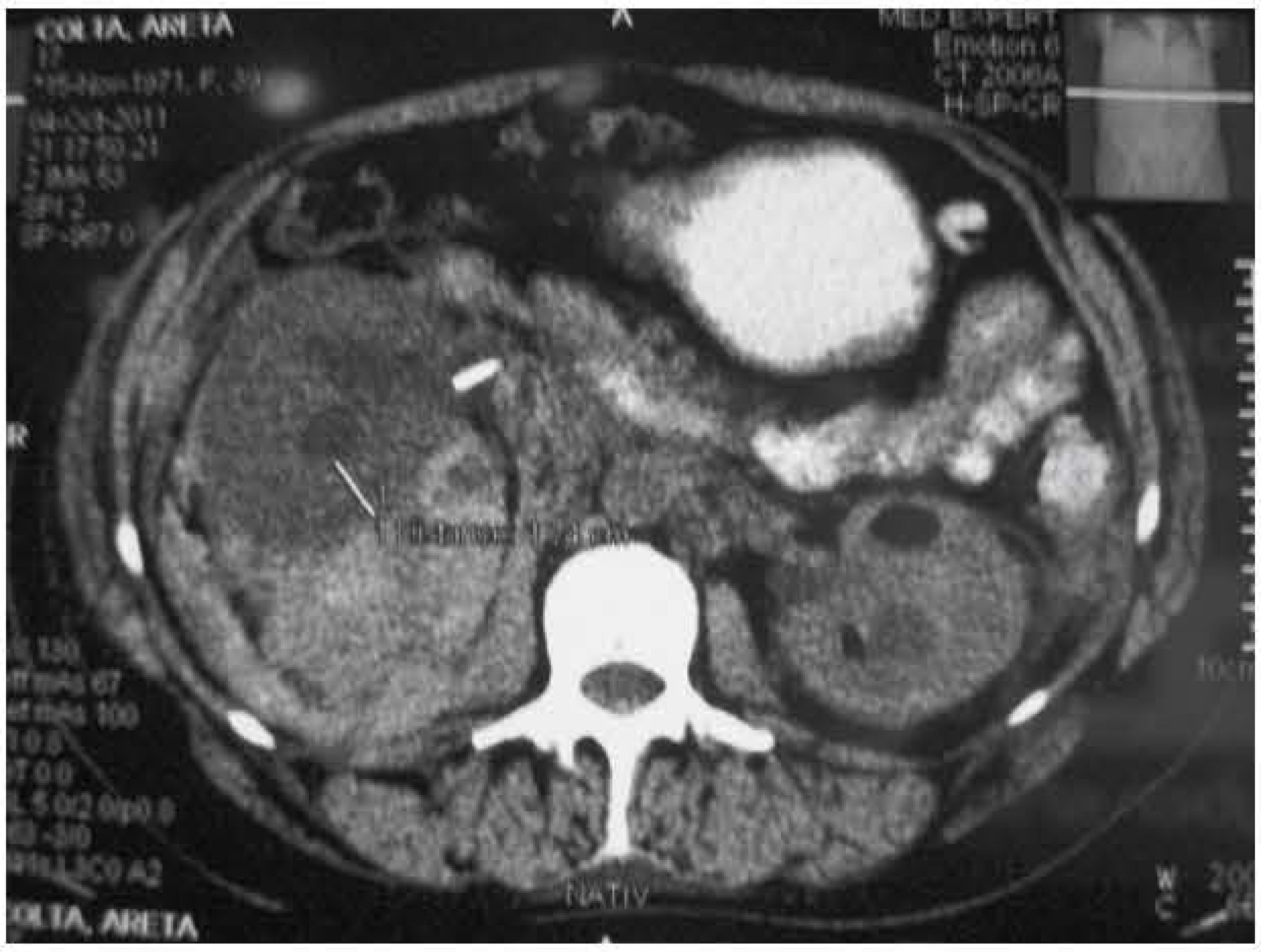

FIGURE 8.5 **Hematoma following percutaneous access to the kidney (computed tomography scan).**

8.6 COMPLICATIONS

Minor complications can occur in 15–25% of cases after percutaneous nephrostomy (Bjarnason et al., 1994; Lang, 1987; Lee et al., 1987). The mortality rate after this procedure is low (0.046–0.3%) (Segura et al., 1985; Lang, 1987; Lee et al., 1987; Stables, 1982). Transient hematuria occurs in almost all cases. Severe bleeding requiring blood transfusions or reintervention occurs in 1–3% of patients (Fig. 8.5). If the bleeding does not stop, we can resort to occlusion of the tube or, in case of failure, an angiography can be performed, followed by an eventual embolization, with surgical intervention rarely necessary (Kessaris et al., 1995).

Instrumenting an infected urinary tract can cause septic complications (1–2.5%) (Dyer et al., 2002); further investigations and interventions can be performed after 48–72 h and only after starting an adequate antibiotic treatment and after clinical stabilization of the patient.

The prevalence of septic complications in patients with pyonephrosis who underwent percutaneous drainage is approximately 25% (Ferral et al., 1994; Cochran et al., 1991).

Other complications that may occur after nephrostomy are represented by the accidental puncture of another organ, such as the retrorenal colon, an uncommon anatomic variant (Hopper et al., 1987; Skoog et al., 1985; Gerspach et al., 1997). Also, hydrothorax or pneumothorax can occur (0.1–0.3%), especially after intercostal approach (Narasimham et al., 1991; Picus et al., 1986).

8.7 RESULTS

Percutaneous nephrostomy is currently one of the most common procedures used for upper urinary tract disobstruction. A nephrostomy catheter can be successfully placed in 98–99% of patients (Stables et al., 1978; Farrell and Hicks, 1997; Lee et al., 1994a,b). This rate can decrease in the case of a nondilated pyelocaliceal system or in patients who present complex lithiasic disease or staghorn calculi.

Thus, the success rate reaches 98% in the case of a dilated system without lithiasis or for a dilated system in the case of a transplanted kidney. However, the success rate can reach 85% in patients with a nondilated pyelocaliceal system (with or without lithiasis) or in the presence of multiple or staghorn lithiasis (Ramchandani et al., 2003).

Urinary tract obstructions, intrinsic or extrinsic, determined especially by stones or neoplasia, are the cause of over 87% of all nephrostomies performed in certain centers (Stables et al., 1978; Stables, 1982; Farrell and Hicks, 1997; Lang and Price, 1983).

In the case of urinary lithiasis, nephrostomy can represent the first step in its treatment. It is also indicated if it is impossible to place a ureteral stent by retrograde approach.

Infected hydronephrosis or pyonephrosis presents a high risk of sepsis (especially with Gram-negative germs), in these cases nephrostomy being accepted as the only emergency interventional solution (Yoder et al., 1983, 1984; Camúñez et al., 1989; Pearle et al., 1998). Frequently, urinary lithiasis is responsible for more than 50% of these cases.

Different instillation therapies can be applied through this method, such as the treatment of some infections (e.g., fungi), injection of bacillus Calmette–Guerin in urinary tract cancers, or of chemolytic agents to dissolve the lithiasic fragments.

The minimally invasive percutaneous approach frequently represents the most appropriate therapeutic solution for proximally migrated or fractured ureteral stents (a subject which is addressed in the chapter dedicated to the percutaneous treatment of iatrogenic lesions).

Regarding urinary fistulas, percutaneous nephrostomy should be associated with other procedures to obtain a total urinary diversion.

Intractable hemorrhagic cystitis may benefit from percutaneous drainage (Zagoria et al., 1993).

The indications of percutaneous nephrostomy in the case of the transplanted kidney are generally identical to those for a native kidney (List, 1989; Bennett et al., 1986). In selected cases, nephrostomy can be performed to differentiate the renal failure caused by obstruction from the one due to rejection.

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CHAPTER

9

Percutaneous Approach of Renal Cysts

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9.1 GENERALITIES

The serous cyst of the kidney is a benign tumor, characterized by the presence of a cavity filled with serous fluid, which does not communicate with the collecting system, having a wall composed of fibrous tissue, lined by a flat cuboidal epithelium and which can compress the adjacent renal parenchyma.

Most commonly they are discovered accidentally during renal imaging examinations. Thus, with the diversification and modernization of the methods for assessing the urinary tract, the detection rate of renal cysts has increased significantly.

The serous cyst is an incompletely elucidated pathological entity. The studies regarding the epidemiology, ethiopathogenesis, diagnosis, and treatment of this disease are not uniform, their conclusions being sometimes divergent. They are considered to be acquired lesions that probably develop from obstructed ducts or tubules. The incidence of cysts increases with age, being approximately 27% at 40 years of age and reaching 61% at 80 years (Carrim and Murchison, 2003). Epidemiological studies have shown a higher incidence in men (Baert and Steg, 1977). Cysts can be associated with genetic predispositions, as in the case of autosomal dominant polycystic disease. Simple cysts can be solitary or multiple, unilateral or bilateral.

From a pathological point of view, the term “simple cyst” is preferred when describing isolated masses filled with serous fluid. It can occur inside the renal parenchyma or on the surface of the kidney. It can be round or oval, with a smooth outline, delimited by a single thin layer of cuboidal epithelial cells and containing clear transudate or yellow-citrine fluid. Although it supposedly originates from a part of the nephron, there is no connection to any of its segments.

Most cysts are smaller than 2 cm and are asymptomatic (Laucks and McLachlan, 1981). In evolution, spontaneous rupture of the cyst into the renal collecting system or the perinephric space can occur. This possibility is due to the increase in pressure, as well as to the intracystic bleeding and changes in the composition of the cyst’s fluid. After rupturing, the cyst can regress or disappear completely.

9.2 THERAPEUTIC INDICATIONS

Despite the fact that the number of cysts and their volume increases over time, most of them are clinically insignificant and do not require any kind of treatment (Terada et al., 2008). The interventional treatment of simple cysts is indicated either when they are symptomatic or complicated, or if the imaging explorations raise the suspicion of an associated tumor pathology.

The therapeutic alternatives for the serous cyst of the kidney are represented by:

- waiting and periodic ultrasound control for small, asymptomatic cysts.
- percutaneous approach of cysts, including puncture for evacuation, fenestration, marsupialization, or endoscopic mucosal fulguration. Ultrasound-guided puncture is recommended for symptomatic cysts. In this situation the biochemical, bacteriological, and cytological examination of the cyst’s content is mandatory. After the cyst’s aspiration, sclerosing substances are inserted into the residual cavity.

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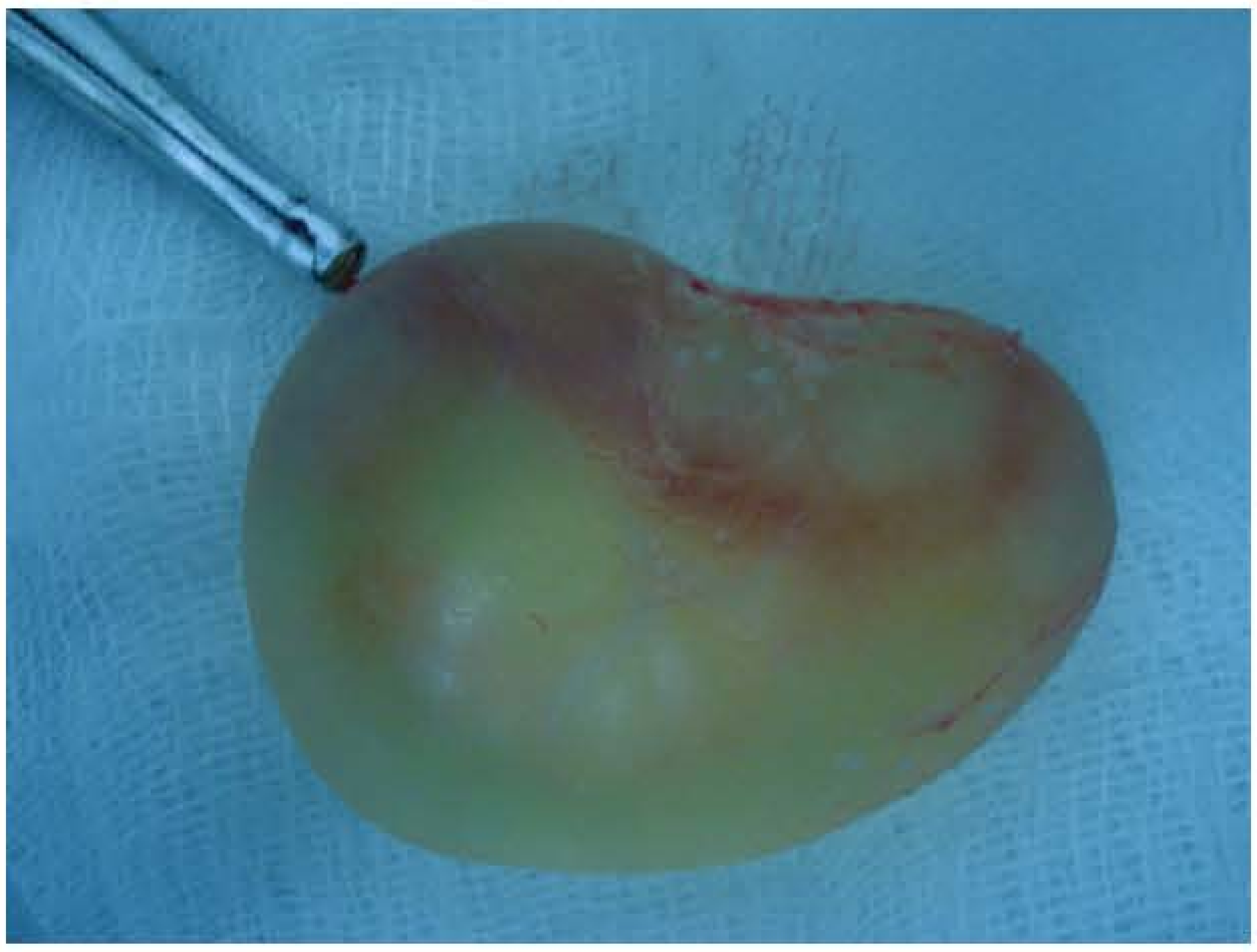

FIGURE 9.1 **Renal cyst (surgical specimen).**

- laparoscopic approach performed transperitoneally or retroperitoneally, depending on the dimensions and topography of the cyst, through which the cystic wall is resected at the limit with the renal parenchyma. After performing the procedure, the histological examination of the cystic wall is required.
- classic open surgery, used in large, infected, complicated cysts. Depending on the local lesions, a total (Fig. 9.1) or subtotal resection of the cyst, or a partial or total nephrectomy, is performed.

In 1986, Bosniak imagined a classification for cysts, dividing them according to their imaging aspects into surgical and nonsurgical.

Thus, category I includes simple cysts, with a thin wall without septa, calcifications, or solid components. The intracystic fluid's density is similar to water and the aspect does not change after administering contrast medium. The risk of malignancy for these cysts is lower than 1% and does not require follow-up.

Category II includes cystic masses smaller than 3 cm, delimited by a thin wall that can present several septa under 1 mm, with or without fine calcifications. The density may be slightly increased (over 20 HU), the cystic margins are smooth, and the content does not change after administering contrast medium. Their risk of malignancy is of approximately 3%, requiring only follow-up, without the need for surgical exploration.

For example, when all the criteria for a simple cyst are met, excepting the existence of a fine layer of calcium in the cystic wall, the lesion can be considered a benign cyst and does not need to be explored.

Category IIF is characterized by the presence of multiple thin septa. They have a reduced thickness or a slightly thickened wall. Calcifications can be nodular or thickened, without enhancement after administering contrast medium. Also, there are no tissue elements which are enhanced after administering contrast medium.

Category III includes cystic lesions with irregular thickening of the walls or septa that are enhanced after administering contrast medium. Also, extensive, irregular, thick calcifications of the walls may appear. These injuries require a surgical approach, the risk of malignancy ranging from 40% to 60%.

Category IV includes cystic tumoral masses with enhancement after administering contrast medium, those with irregular margins or protruding nodules. The risk of malignancy is higher than 80%, requiring surgical treatment.

The main problem is choosing the therapeutic options in borderline cases which exist between category II, which only requires follow-up, and category III, which requires surgical exploration. This problem relates to the fact that there is no classification of cysts with septa that are too thick or with too much calcium.

The surgical indication of a benign renal cyst is established according to its volume and the disturbances that it causes. It is preferred that the cyst remain in place if asymptomatic, after the suspicion of a tumor is excluded (Gordon et al., 1979).

The interventional treatment of simple cysts may be necessary when infection, arterial hypertension, or urinary tract obstruction are associated. Intervention may also be necessary in the case of voluminous cysts, those causing pain, or those that manifest as a palpable tumor mass (Evans and Coughlin, 1970; Chan and Kodroff, 1980).

There are no clear criteria for choosing the therapeutic option according to the case's characteristics. Factors related to clinical manifestations, imaging aspects, associated conditions, as well as the informed patient's preference, are all involved in the therapeutic decision.

Evacuation by ultrasound-guided percutaneous puncture has the advantage of being easy to perform, with minimal morbidity, but is associated with an increased risk of recurrence, particularly in the case of voluminous cysts.

The absolute contraindication for percutaneous puncture of the cyst is represented by its communication with the pyelocaliceal system.

Cystotomy consists of the partial resection of the cyst achieved by unroofing the cyst, followed by hemostasis of the sectioned area. In some cases it is also recommended to fulgurate the mucosa remaining in the cystic cavity from inside the parenchymal area, a wall that cannot be removed, as it is adherent to the renal parenchyma. Performing it laparoscopically allows for a reduction in the intervention's morbidity and a quick social reintegration.

Nephrectomy is indicated when the cyst is complicated or when the kidney is morphofunctionally compromised.

9.3 PREOPERATIVE EVALUATION

A serous cyst of the kidney can be assessed by clinical and imaging methods.

Simple renal cysts usually have a discrete symptomatology. They may be accidentally discovered during ultrasound, computed tomography (CT), or intravenous urography performed for a different abdominal or pelvic condition.

9.3.1 Clinical and Laboratory Evaluation

Although the absence of symptoms for renal cysts has been mentioned, this applies only to small cysts, generally less than 5 cm in diameter. With the increase in size, due to the mechanical effect on the surrounding areas, clinical manifestations may occur. Thus, cysts may determine the presence of a palpable abdominal mass, pain, hematuria secondary to rupture into the pyelocaliceal system, hypertension secondary to segmental ischemia (Rockson et al., 1974; Lüscher et al., 1986; Papanicolau et al., 1986), or increase of the hematocrit (Wolf, 1998). Cysts may also cause urinary tract obstruction (Wahlqvist and Grumstedt, 1966; Evans and Coughlin, 1970; Hinman, 1978).

Exceptionally, upper renal cysts may compress the diaphragm with the appearance of dyspnea, while lower cysts can sometimes lead to intestinal obstruction or compression of the inferior vena cava.

In the case of complicated serous renal cysts (hemorrhagic, infected), there may be pain and sometimes impastation at palpation in the lumbar area.

Parapyelic cysts are generally solitary and compress the renal sinus elements (pyelocaliceal system, renal vessels), which can lead to hypertension due to the Goldblatt phenomenon.

Inconstant changes can appear with regard to urine analysis, such as albuminuria or hematuria.

9.3.2 Imaging Evaluation

The imagistic diagnosis of serous cysts can be achieved by: ultrasound, Doppler ultrasound, intravenous urography, CT, and magnetic resonance imaging (MRI).

Ultrasound is the most efficient way of confirming a cyst. When all the criteria for the presence of a benign cyst are met (Fig. 9.2), further evaluations are not indicated (Krambeck and Lingeman, 2012).

The ultrasonographic diagnosis of a simple renal cyst is made by the following criteria (Fig. 9.3):

- the absence of internal echoes
- thin wall, well-defined, distinctive, with smooth margins
- a good transmission of the ultrasonic waves through the cyst, with acoustic amplification behind the cyst
- spherical, oval shape (Goldman and Hartman, 1990)

If these criteria are met, the risk of malignancy is very low. When some of these criteria are absent and there are some changes such as: the presence of septa, irregular margins, calcifications, or modified areas, evaluation by CT, MRI, or puncture–aspiration is recommended (Bosniak, 1986).

Doppler ultrasound may be useful to detect neovascularization in the case of intracystic tumors (Krambeck and Lingeman, 2012).

In the case of a cystic or massively necrosed tumor, Doppler ultrasound (Fig. 9.4) can perceive flow signals in the wall or inside the tumor, but remains less sensitive than CT or MRI. The sensitivity and specificity of the tumor's assessment are improved by "power Doppler" and the use of contrast medium (Krambeck and Lingeman, 2012). The use of tridimensional ultrasonography can provide additional elements to the spatial assessment of cysts (Fig. 9.5).

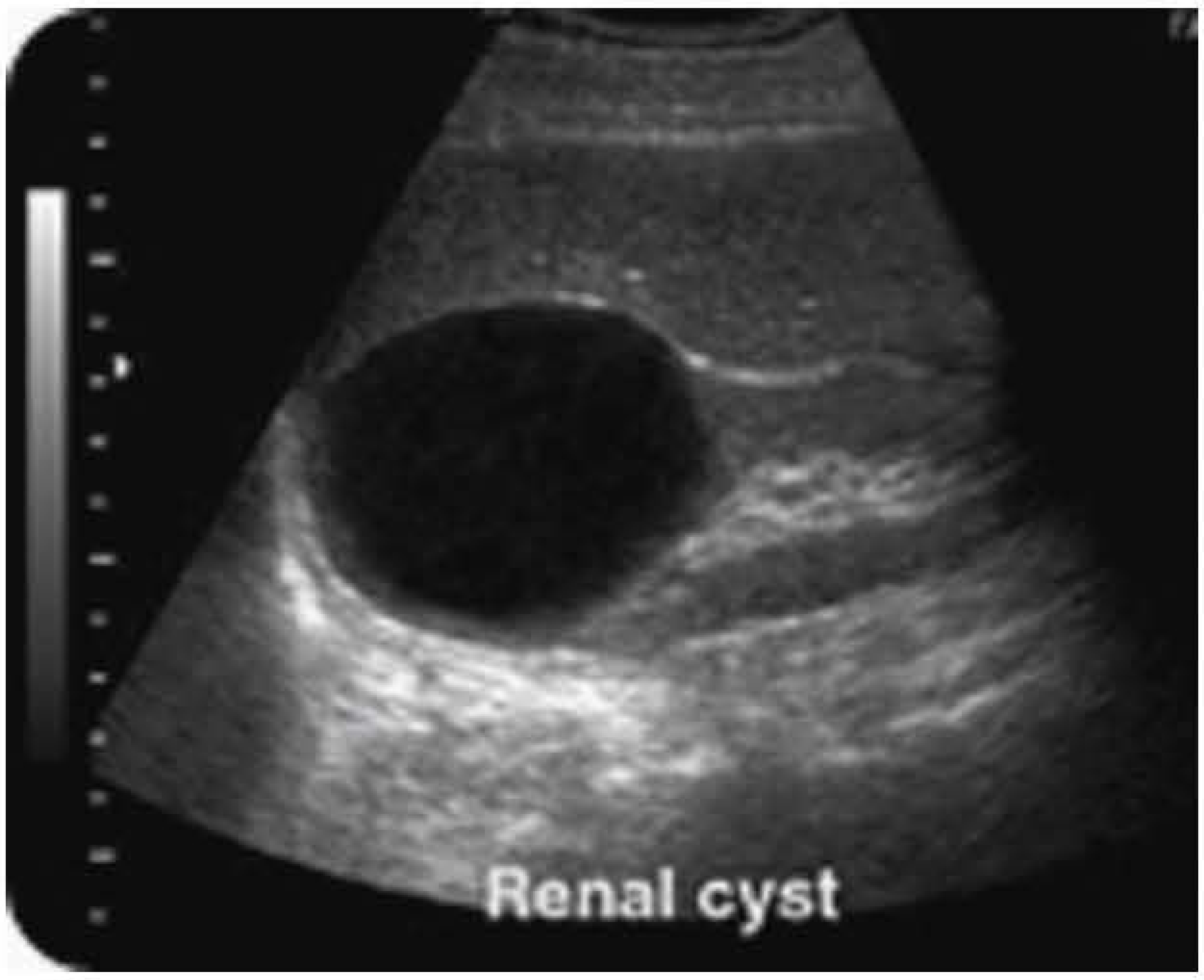

FIGURE 9.2 Serous renal cyst (ultrasound aspect).

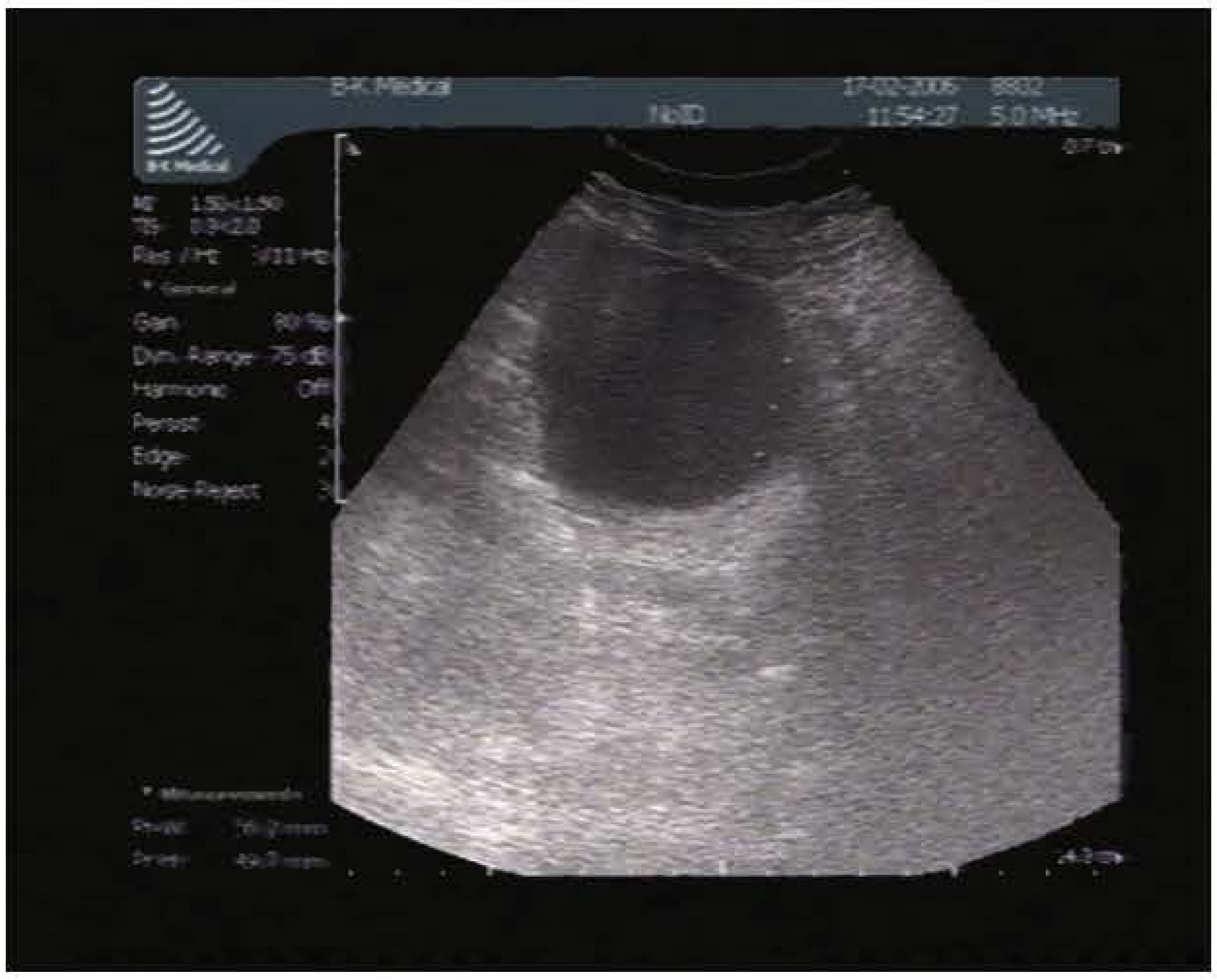

FIGURE 9.3 Ultrasonographic characteristics of a simple renal cyst.

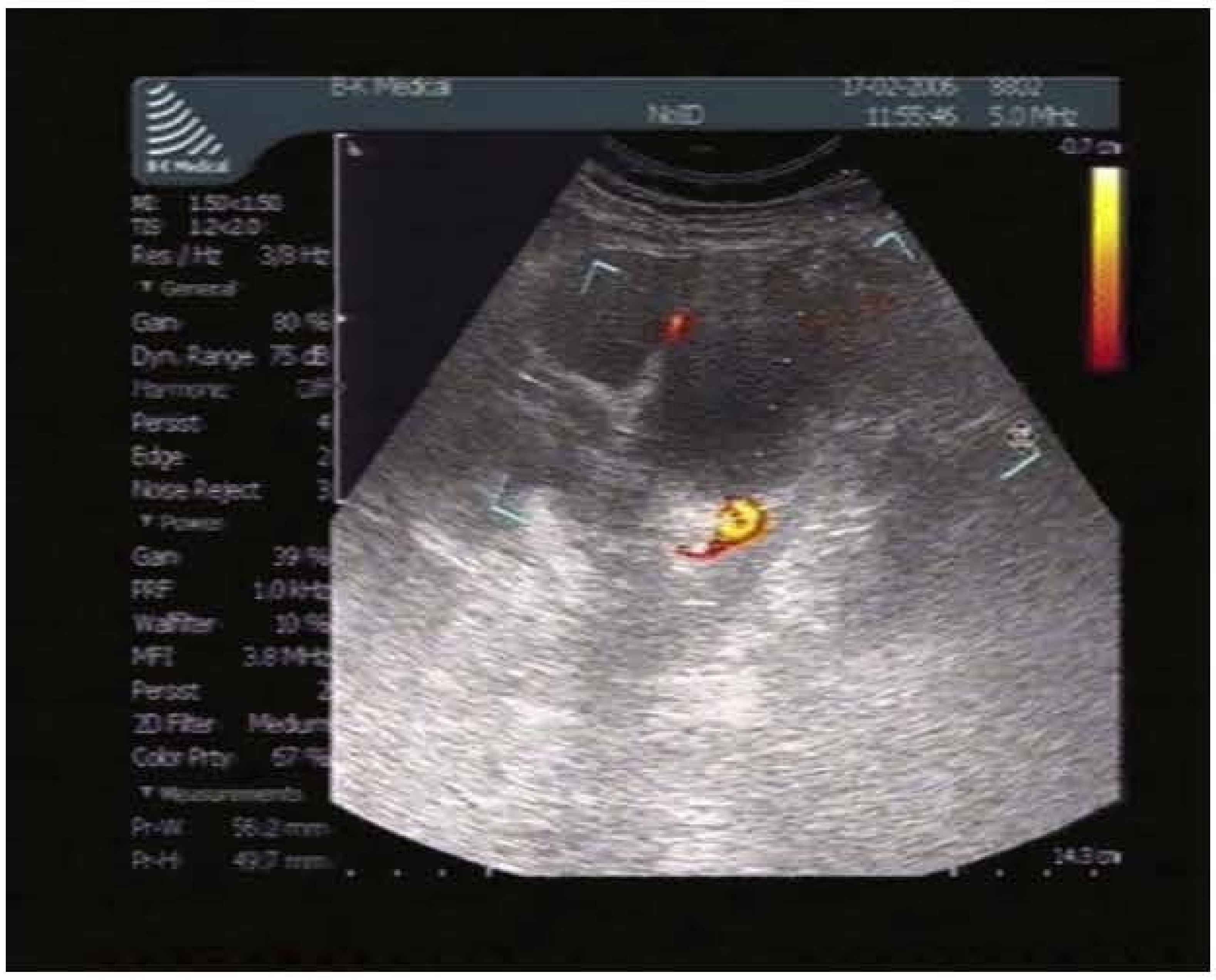

FIGURE 9.4 Power Doppler ultrasound revealing pericystic vascularization.

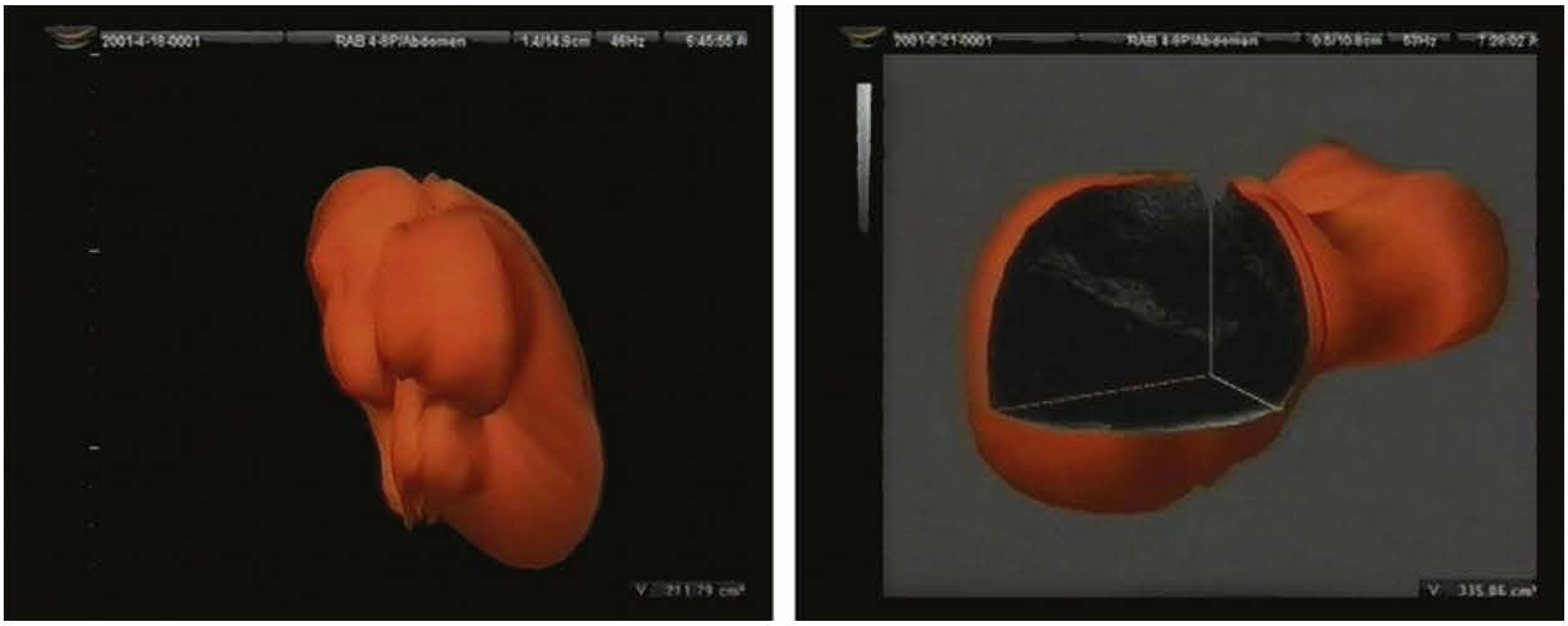

FIGURE 9.5 Tridimensional reconstruction of a kidney with an upper polar renal cyst and assessment of the cyst's content and its wall by tridimensional slices.

The presence of a malignant cystic tumor can be detected by highlighting a thickened cystic wall, sometimes with a neoplastic nodule of the wall and irregular margins. In the case of a difficult differential diagnosis (hemorrhagic or infected cyst), a diagnostic puncture can be performed under ultrasonographic control.

Intracystic bleeding determines changes to the content's echogenicity, thickening of the wall, and the appearance of marginal calcifications. It is difficult to differentiate an infected cyst from a renal abscess by imagistics.

CT (Fig. 9.6) is used when ultrasound offers unsatisfactory results. Another indication for CT exploration is the presence of a cluster of cysts (Bosniak, 1986).

The presence of a benign serous cyst is suggested by: thin, distinctive, smooth cystic walls, spherical or oval shape of the mass, homogeneous content with a density between 10 HU and 20 HU (density similar to water) (Heneghan et al., 2002; Geavlete and Georgescu, 1999).

On MRI examination, the serous cyst has a low intensity in T1 and increased intensity in T2. It appears as a homogeneous, round mass with a thin wall, surrounded by normal renal parenchyma (Fig. 9.7).

Urography has limited use in the diagnosis of serous cysts, providing indirect data regarding its presence, but is important for assessing the impact of the cystic mass on the urinary tract (Fig. 9.8).

The urographic diagnostic criteria for serous renal cysts are (Fig. 9.9):

- transparent area in the renal parenchyma
- existence of a thin interface surrounding the normal renal cortex
- presence of an excrescence when it extends beyond the kidney's surface

If a cystic rupture leads to a communication with the collecting system, it is detected by intravenous urography or retrograde pyelography due to the opacification of the cystic cavity.

Sometimes, a scintigraphy with isotopic nephrogram may be necessary to evaluate the renal function.

When the cyst is not well defined, the most important issue is represented by potential intracystic tumors, in which case a diagnostic puncture can be useful.

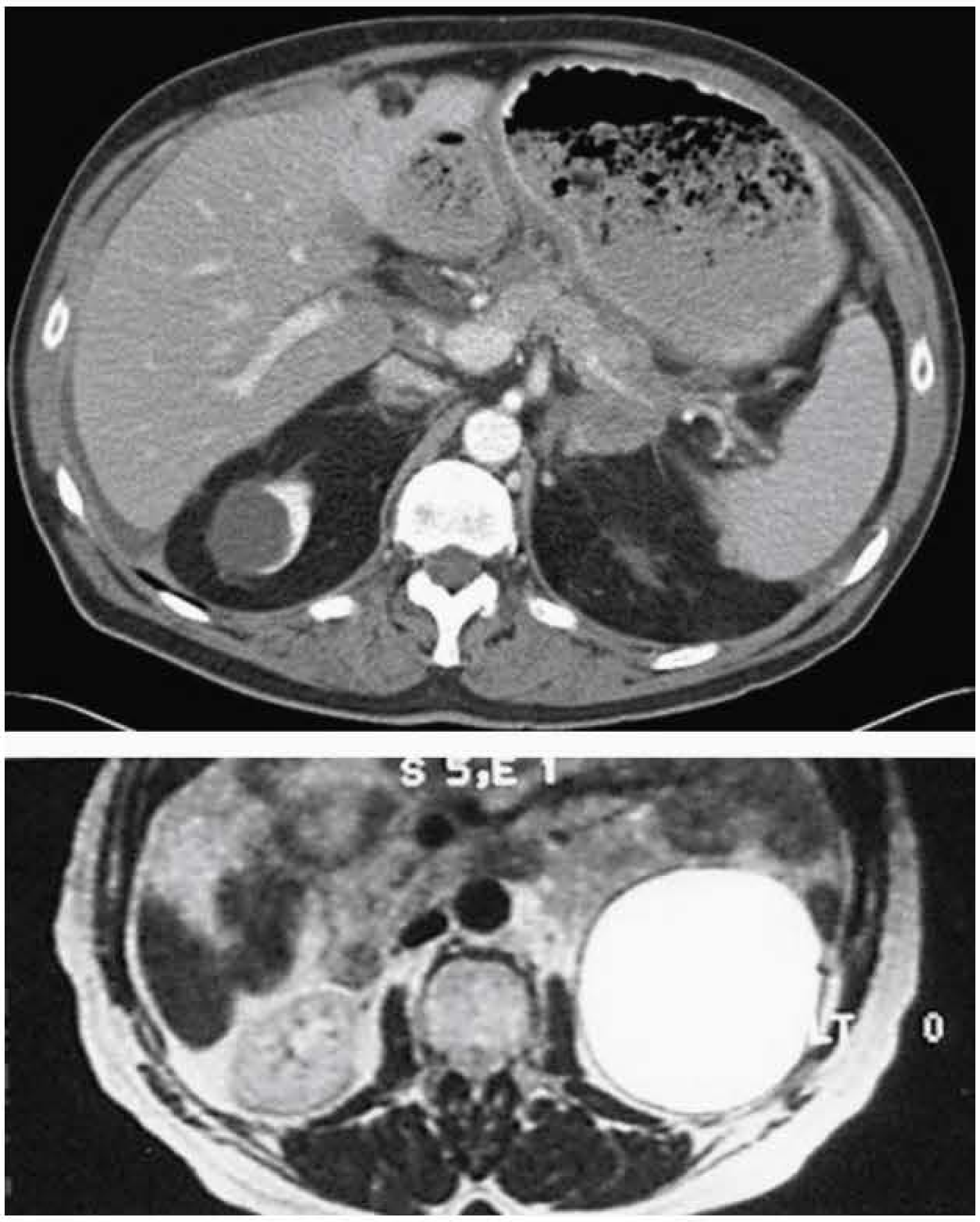

FIGURE 9.6 CT aspect of a simple renal cyst.

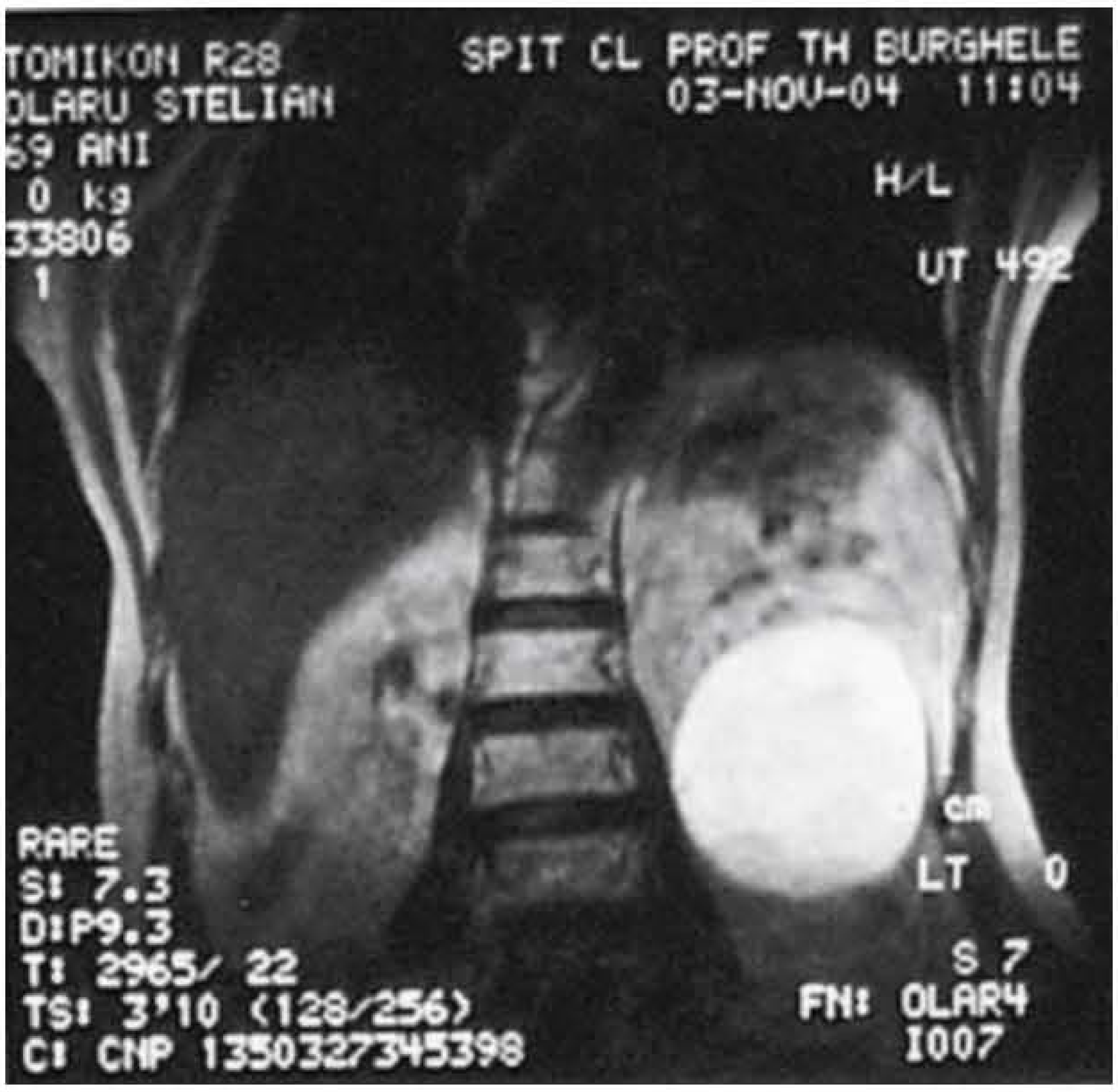

FIGURE 9.7 MRI aspect of a simple serous cyst.

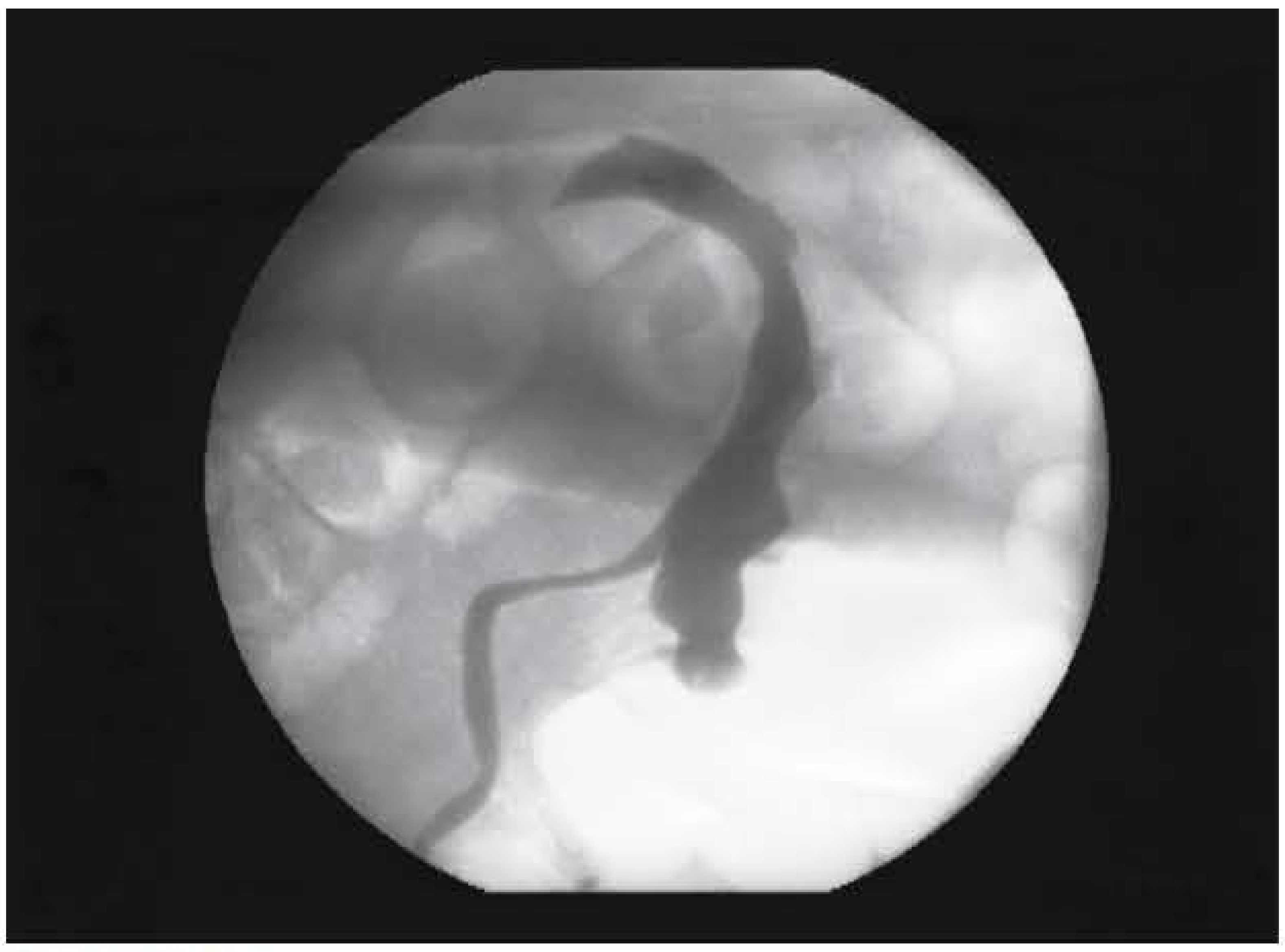

FIGURE 9.8 **Change in the pyelocaliceal system's architecture determined by the presence of a serous cyst (urographic aspect).**

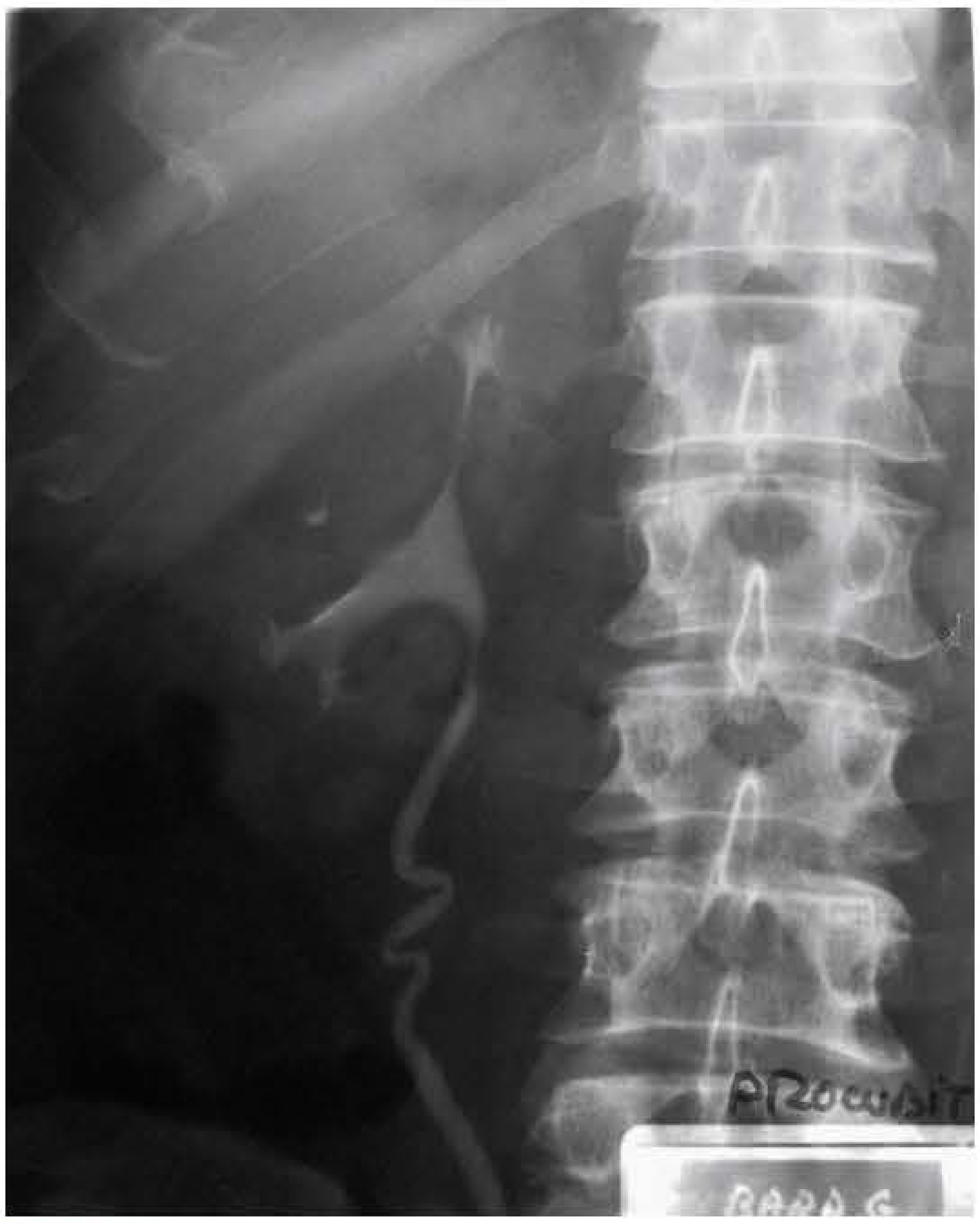
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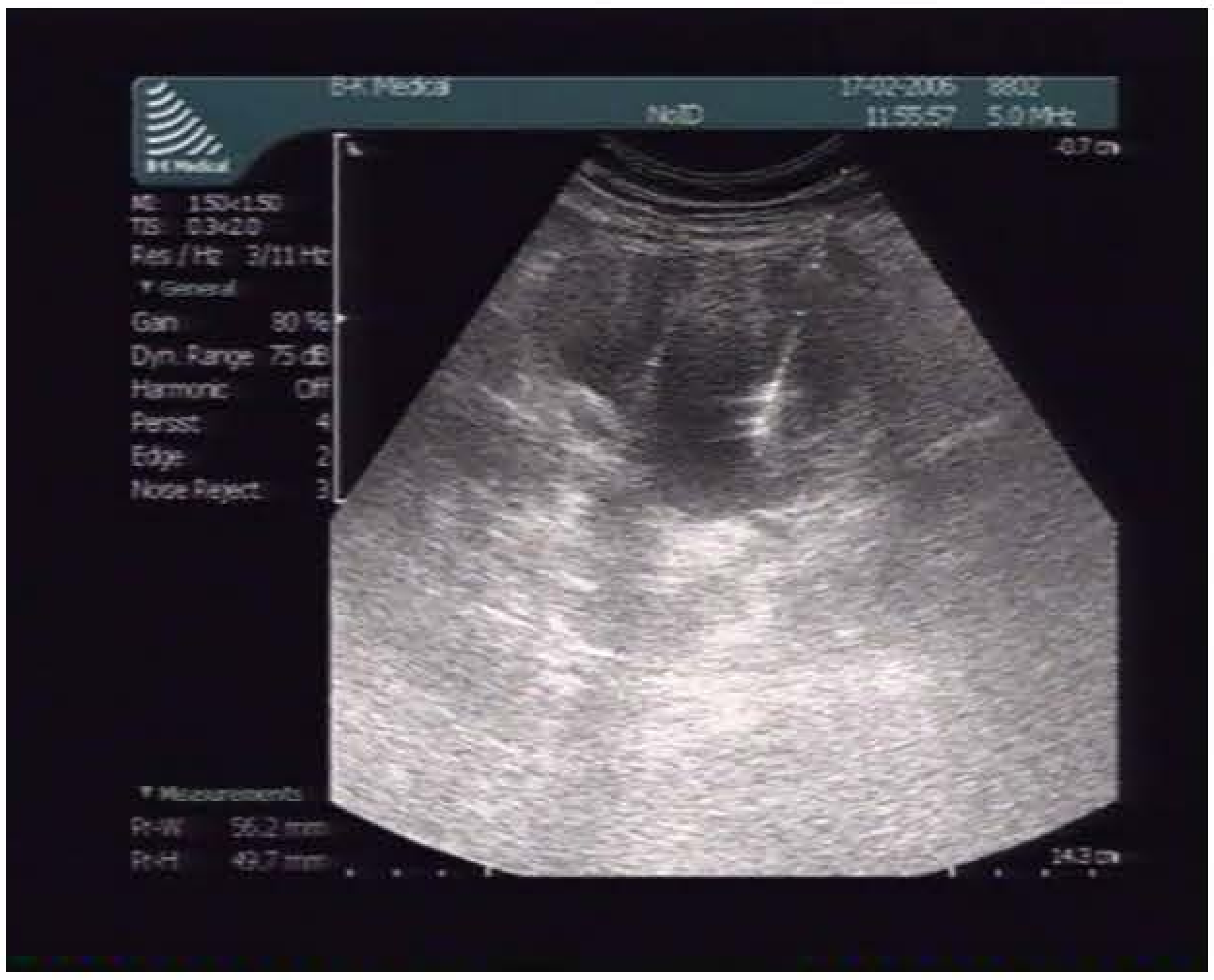
FIGURE 9.9 **Urographic aspect determined by the presence of a serous cyst.**

9.3.3 Puncture and Aspiration of the Cyst for Diagnostic Purposes

The puncture of the cyst and the aspiration of its content (Fig. 9.10) represented a frequently used diagnostic method until the 1970s.

With the widespread use of ultrasound and CT, the indications for puncture of the cyst for diagnostic purposes are limited. Currently, they are represented by:

- probability of an intracystic infection, the puncture having diagnostic and therapeutic purposes
- presence of low echoes, but with a CT aspect of a classic cyst
- borderline lesions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Gain 80 %
Dyn. Range 75 dB
Harmonic Off
Persist 4
Edge 2
Noise Reject 3
▼ Measurements
Fr-W 56.2 mm
Fr-H 49.7 mm
14.3 cm

FIGURE 9.10 **Ultrasound-guided puncture of a renal cyst.**

In cases of hyperdense cysts larger than 3 cm, the following options can be considered:

- puncture with aspiration for cytological study
- puncture with injection of contrast medium
- surveillance of the cysts at various intervals, using ultrasound or CT

When fluoroscopically or ultrasonographically guided puncture is performed, a control cystography (Fig. 9.11) can also be carried out to reveal dendriform tumors (Sinescu, 1998).

The fluid content of neoplastic cysts can be hemorrhagic or can have high levels of proteins, lactate dehydrogenase, or fats (Marotti et al., 1987).

When assessing an infected cyst, the fact that its wall can be thinned and sometimes calcified should be taken into account. Calcification can also be present in the absence of infection or neoplasia, about 1–3% of simple renal cysts being calcified (Daniel et al., 1972; Bree et al., 1984).

Calcification is dystrophic and commonly occurs secondary to bleeding, infection, or ischemia (Hartman, 1990). Thus, 6% of simple cysts can be hemorrhagic (Jackman and Stevens, 1974), and approximately 31% of hemorrhagic cysts are neoplastic (Gross and Beach, 1971).

Even if bleeding is present, the surgical decision is based on the ultrasound or CT exams.

9.4 OPERATIVE TECHNIQUE

9.4.1 Puncture Followed by Sclerosis of the Cavity

The intervention can be performed on an outpatient basis or in a day hospitalization regimen. Usually, preoperative prophylactic antibiotic treatment is recommended.

The percutaneous approach of serous renal cysts is usually done under local anesthesia with 1% lidocaine. For upper renal pole or mediorenal cysts, epidural anesthesia can be used.

The patient is placed on the radiological table in ventral or lateral decubitus. The first step of the intervention consists of the ultrasound evaluation, necessary for orientation and for establishing the percutaneous puncture site.

Ultrasound-guided puncture–aspiration is then performed, and the sclerosing substance is injected. Ultrasonographic monitoring allows tracking of the needle until it enters the cystic cavity, where it appears as a bright spot (Fig. 9.12).

The aspiration of the cyst can be performed through the puncture needle or through a mono J catheter. Performing aspiration through the needle has the advantage of making a small sting, thus being less aggressive and painful. Due to its rigid structure, it can be easily guided by ultrasound, the aspiration of the entire cystic content being possible (Boja, 2000).

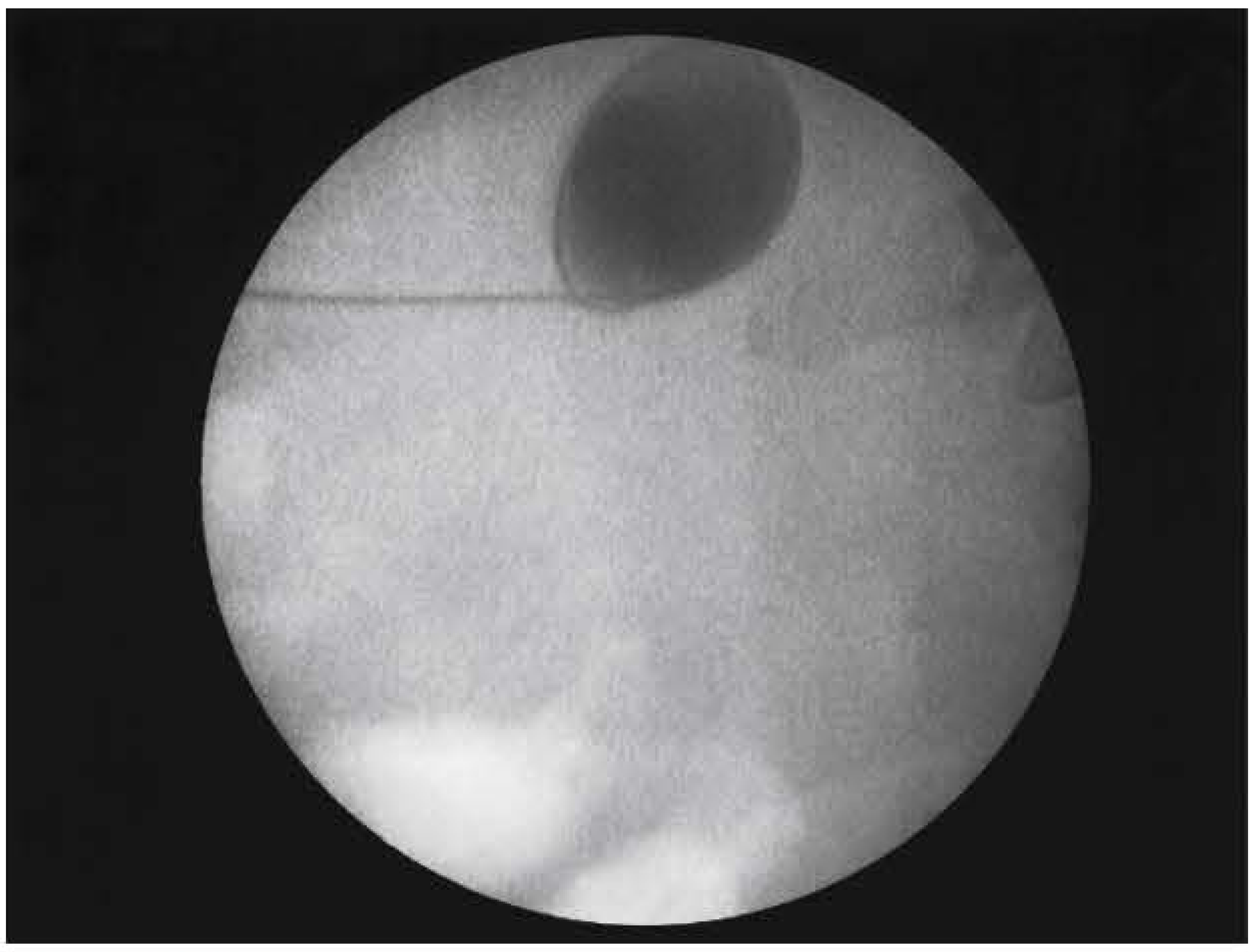

FIGURE 9.11 **Assessment of the cyst by cystography.**

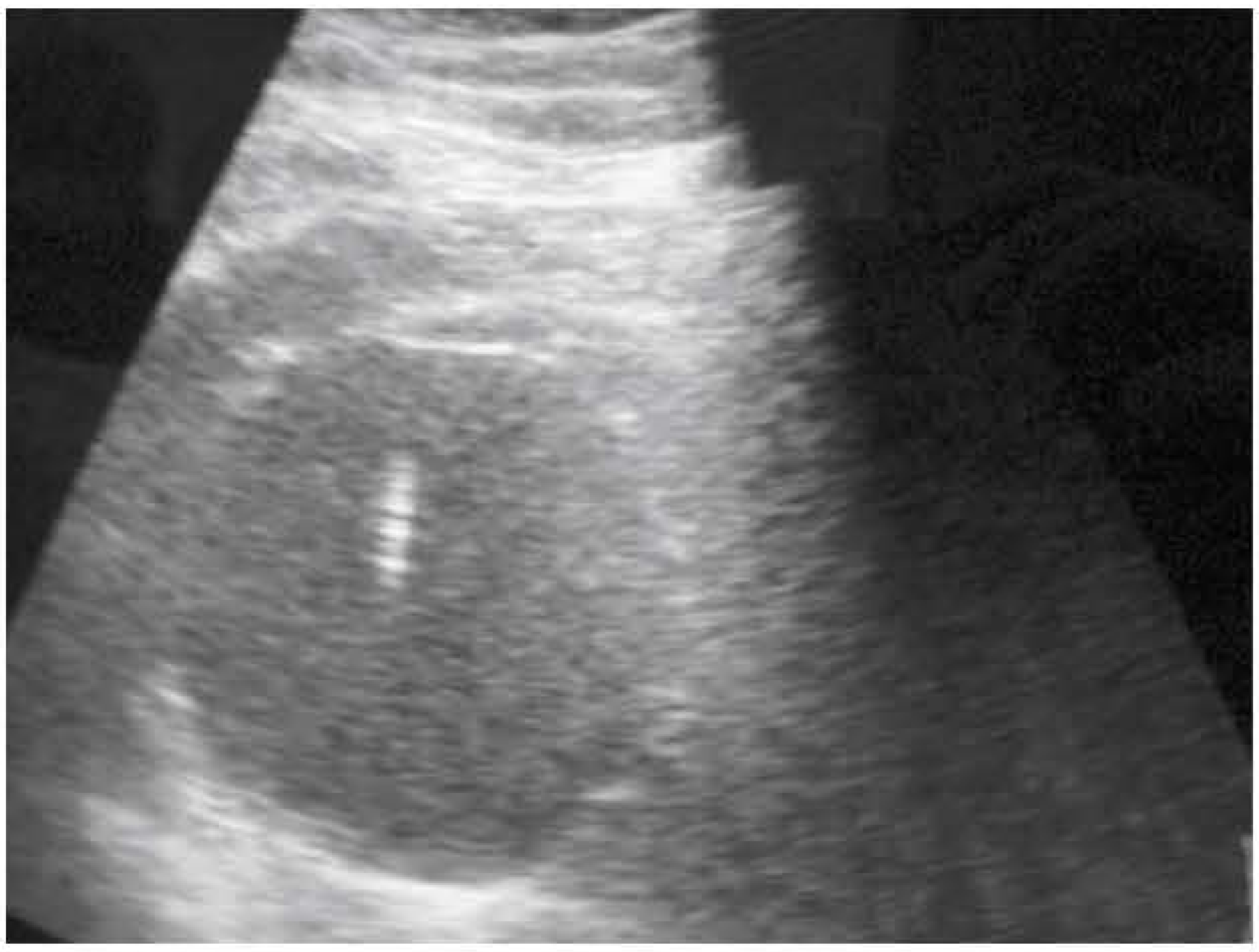

FIGURE 9.12 **Intracystic aspect of the puncture needle.**

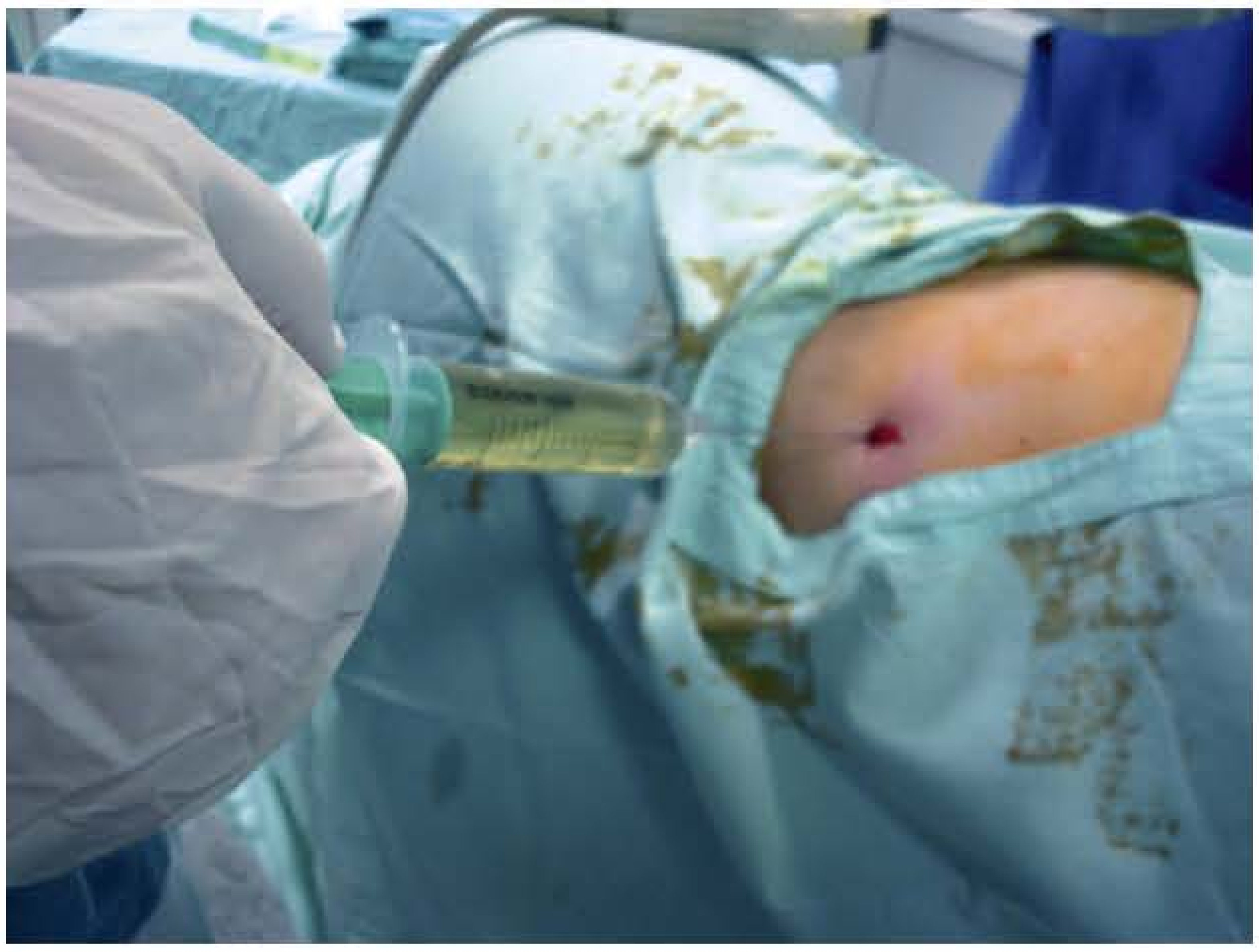

FIGURE 9.13 **Cystic fluid aspiration.**

Many authors support contrast medium injection to exclude the existence of a communication with the collecting system. If the pyelocaliceal system communicates with the cystic cavity, intracystic injection of the sclerosing agent is contraindicated.

Thus, after performing the puncture, it is recommended to collect intracystic fluid for bacteriological and cytological examinations, after which approximately 10 mL of contrast medium are injected through the needle for the fluoroscopic evaluation of the contour of the cyst and of the walls (Boja, 2000).

Aspiration of the intracystic fluid under ultrasound control is performed subsequently, until the transonic cavity disappears (Fig. 9.13).

To prevent recurrence of renal cysts, it is necessary to destroy the cystic epithelium. Sclerotherapy using various sclerosing agents is used to achieve this goal. Their use is mandatory because, if only drainage of the cyst is performed, it will return to the dimensions prior to the procedure in approximately 90% of cases (Wolf, 1998).

The sclerosing substances used by different authors (Holmberg and Hietala, 1989; Ohkawa et al., 1993; Yamamoto et al., 2005; Phelan et al., 1999; Kim et al., 2004; Paananen et al., 2001; Seo et al., 2000; Boja, 2000) have been represented by:

- bismuth phosphate
- minocycline HCl
- ethanolamine oleate
- povidone iodine
- beta-emitting radionuclide (holmium-166-chitosan complex)
- ethanol
- acetic acid
- autologous blood
- hypertonic glucose
- lipiodol
- pantopac
- solvocilin
- dextrose
- aethoxysklerol
- tetracycline
- bleomycin
- iofendylate
- phenol
- urea chlorohydroxilactate
- *n*-butyl-cyanoacrylate, etc.

The amount of sclerosing substance introduced into the cystic cavity after aspiration depends on the size of the cyst, representing 5, 10, or 15% of the volume of the cystic fluid that was aspirated, while other authors recommend injecting an amount equal to one-third or half of the cyst's volume, but not more than 100 mL.

The sclerosing substance is injected also under ultrasound control, to certify the intracavitary presence of the needle tip.

The most commonly used sclerosing agent is pure alcohol. This does not involve any special preparation or dilution. Its use does not give rise to complications, and its concentrations in the serum and urine are acceptable (0.3 and 0.27 g/L, respectively). Also, there are no signs of intoxication secondary to the presence of alcohol in the cystic cavity. Although the systemic diffusion of alcohol may induce central nervous system depression, no side effects are observed in patients who undergo sclerotherapy with alcohol (Boja, 2000).

Alcohol acts by affecting the secreting cells of the cystic epithelium. After 3 min of contact with alcohol, the epithelial cells lining the cyst become fixed, and the cyst's capsule is penetrated after 4–12 h. The low success rates after a single session of sclerotherapy, when the sclerosing agent is aspirated from the cyst, may lead to the conclusion that the epithelial cells were not affected enough.

Similarly, endocavitary injection of aethoxysklerol produces an aseptic thrombophlebitis limited to the cyst's mucosa, followed by mucosal sclerosis (Boja, 2000).

Another technical variant for carrying out the procedure consists of replacing the needle, after the puncture, with a mono J catheter, through which the cyst's content is aspirated and contrast medium is introduced to perform cystography. After complete aspiration of the cyst, the sclerosing agent is injected.

Many methods for achieving drainage and for sclerosing the cystic cavity have been described, without being able to determine the optimal alternative with certainty.

Touloupidis et al. (2004) recommend drainage of the cyst for 24 h and subsequent injection of the sclerosing agent, while De Dominicis (2001) proposed aspiration of the cyst and introduction of the sclerosing substance, followed by aspiration of the cavity for 24–48 h.

The insertion of a mono J catheter into the serous renal cyst and applying the procedure several times increases the efficiency of sclerotherapy, decreases the number of relapses, but also increases the costs and morbidity (Chung et al., 2000). Thus, a method described in the literature consists of inserting an amount of pure alcohol equivalent to a quarter of the cyst's volume, but not more than 100 mL. It is maintained inside the cavity for 20 min, after which it is aspirated. If the cyst's volume is less than 100 mL, the authors recommend to repeat the procedure, while for larger ones, to inject alcohol three times. Thus, Fontana et al. (1999) proposed the evacuation of the cyst, followed by three injections of the sclerosing agent lasting 20 min each, at 24-h intervals.

Postoperative follow-up is performed by physical examination and ultrasound at 3, 6, and 12 months after sclerosis of the cyst (Boja, 2000).

9.4.2 Other Alternatives of Percutaneous Treatment

Other alternatives of percutaneous treatment for renal cysts (Plas and Hübner, 1993) include:

- fenestration
- marsupialization
- endoscopic mucosal fulguration (Boja, 2000; Kang et al., 2001)

The percutaneous approach of the cyst for fenestration of the wall or the endoscopic resection of the cyst's dome are indicated only for cysts located on the posterior half of the kidney's valve.

The procedure can be performed under general or spinal anesthesia. Cystic wall fenestration implies ultrasound-guided puncture of the cyst as the first operative step. Once the needle has penetrated the cystic cavity, the intracystic fluid is aspirated and the contrast medium is injected.

Once the cyst is fluoroscopically checked, a guidewire is inserted inside the cystic cavity. A 1-cm incision of the skin is performed at the puncture site. After insertion of the guidewire, the puncture needle is extracted and the dilation of the tract is performed, through which a 28 F Amplatz sheath is inserted. The intervention is performed with a 26 F resectoscope. The interior of the cystic cavity is inspected using the resectoscope, so that any modification of its mucosa can be identified. Three or four incisions of the cystic wall are then performed with the Collings loop, at the level of the dome, in the postero-external quadrant. The incisions should have a length of 2.5–3 cm and should be deep enough to allow visualization of the perirenal fat. The distance between the incisions is 2–3 cm. After checking hemostasis, a drainage tube whose distal end is connected to a collecting bag is placed through the Amplatz sheath. The tube is suppressed after 48 h from the intervention. Afterward, the cyst's mucosal secretion is drained through the incisions made in the cystic wall, into the perirenal fat, from where it is drained venously or lymphatically (Boja, 2000). Another modality for the cyst's percutaneous treatment is represented by marsupialization or percutaneous resection of the dome (Kang et al., 2001). Endoscopic resection has operative steps identical to percutaneous fenestration, and is performed with the resection loop and the coagulation roller (Boja, 2000).

Endoscopic mucosal fulguration consists of coagulation of the entire surface of the cystic epithelium (Busato and Bettega, 2010). The resectoscope with the coagulation roller is inserted into the cystic cavity and cauterization of its internal surface is performed. Coagulation must be performed with a low power, adapted during the intervention. For this reason, coagulation begins in the less sensitive areas and ends in the infundibular region. A 20 F Foley catheter is then inserted into the cavity.

9.5 INTRAOPERATIVE AND POSTOPERATIVE COMPLICATIONS

The treatment of renal cysts by puncture, aspiration, and sclerosis involves a minimal risk of developing incidents or complications.

However, data in the literature describe allergic reactions to various substances used and the sclerosis of renal excretory cavities when the cyst communicates with them.

Other complications that can occur are represented by:

- bleeding, with renal colic, due to the passage of clots
- transient hematuria
- puncture of the adjacent organs and vessels
- fever
- pneumothorax – resolved spontaneously or by thoracic drainage (extremely rare) (Silver et al., 1977)
- septicemia

The most frequent complication of this procedure remains the recurrence of the cyst.

Intraoperative incidents and accidents have a higher frequency in the case of treatment by fenestration or resection of the cyst. The most frequent is bleeding during dilation of the puncture tract that can resolve spontaneously or requires surgical hemostasis (Boja, 2000). This complication can occur when a tract is not performed strictly through the cyst's dome and a part of the renal parenchyma is dilated. Bleeding during resection of the cyst's dome is sometimes described, when aberrant renal vessels may be damaged. In some cases, these bleedings can remit spontaneously through self-compression, other times requiring open surgery.

Another incident is represented by duodenum injury during fenestration of large lower pole cysts, when the incision of the cystic wall is made antero-laterally, not postero-externally. This is a serious complication that requires emergency open surgery.

Sometimes severe vascular lesions can occur that can even lead to hemostatic nephrectomy.

Another incident that occurs during the cyst's fenestration consists of the accidental opening of the excretory tracts. The incident is rarely recognized intraoperatively, and in most cases an increase in the amount of fluid evacuated through the drain tube is noticed.

In the case of fenestration or endoscopic resection of mediorenal or upper pole cysts, pleural lesions may occur as complications.

9.6 RESULTS

The treatment of serous renal cysts by percutaneous aspiration and sclerotherapy represents a minimally invasive method performed successfully in most patients with symptomatic renal cysts (Table 9.1). This therapeutic alternative has the advantage of low costs and a reduced rate of complications.

Percutaneous sclerotherapy was first performed by Bean (1981), who performed drainage and injection with alcohol of a symptomatic serous renal cyst.

In most studies, the use of alcohol for achieving cavity sclerosis led to favorable results. The injection of alcohol outside the cyst leads to necrosis of the surrounding tissue; this can be observed by using Doppler ultrasound during the injection.

Sclerotherapy in a single session can be performed with an acceptable long-term success rate and low morbidity, and its effects are amplified by the continuous presence of the sclerosing agent. Thus, Falci-Júnior et al. (2005) obtained a rate of disappearance of symptoms of 93% at 6 months after ethanol injection, without its drainage.

TABLE 9.1 Results of Percutaneous Sclerotherapy of Serous Renal Cysts

Author	Sclerosing substance	Number of injections	Follow-up period	Disappearance of cysts (%)	Disappearance of symptoms (%)
Holmberg and Hietala (1989)	Bismuth-phosphate solution	1	3–4 years	44	
Paananen et al. (2001)	Ethanol	3 × 20 min	1 year	22	75
Touloupidis et al. (2004)	Ethanol	1 × 20 min	5 years	71	83
Fontana et al. (1999)	Ethanol	3	4 years	97	
Porpiglia et al. (1996)	Ethanol	3	28 years	96	
De Dominicis (2001)	Ethanol	1	36 years	76	
Kwon et al. (2007)	50% Acetic acid	1	1 year	66	
Madeb et al. (2006)	Povidone iodine	3	1.8 years		25
Falci-Júnior et al. (2005)	Ethanol	1	6 months		93
Gasparini et al. (2003)	Ethanol	8	1 year	78	100
Choi et al. (2009)	OK-432	1	1 year	75.4	100
Pfister et al. (1996)	Ethanol	1	1 year	90	90

The success rate is lower if the sclerosing agent does not remain in prolonged contact with the cystic epithelium, probably because the epithelial cells were not affected enough. Consequently, the aspiration of the sclerosing agent during the same session is associated with poorer results.

The importance of using sclerosing agents was also demonstrated by a comparative study conducted by Holmberg in 1989. It reviewed a series of 156 patients who were divided into 3 groups according to the treatment applied (Holmberg and Hietala, 1989).

In the first group, no treatment was applied, and in 25% of patients the cysts grew in size within a period of 3 years.

In the second group, in which only aspiration was performed, the cysts disappeared in 10% of patients, while in 90% they decreased in size after 2 years.

In patients from the third group, who underwent aspiration associated with bismuth phosphate sclerotherapy, the cysts remitted in 44% of cases, while in 21% they decreased in size after 3–4 years.

Touloupidis et al. (2004) described better results when the cyst was drained for 24 h, followed by ethanol injection over a period of 20 min. The success rate was higher compared to cases in which the sclerosing agent was introduced immediately after the evacuation of the cyst.

The data in the literature suggest that sclerotherapy performed in several sessions leads to better results than the one performed in a single step (success rate of 57% vs. 95%).

The procedure applied several times implies inserting a Cook catheter into the renal cyst, which leads to an increase in costs and morbidity.

In a study published by Fontana in 1999, using three alcohol injections performed in an interval of 24 h, a rate of disappearance of the cysts of 97% was obtained, results that remained stable over a mean follow-up period of 4 years. Similar results were published by Porpiglia et al. (1996).

The results of a comparative study on the efficiency of simple renal cysts sclerotherapy using alcohol or aethoxysklerol, followed by prolonged drainage (7 days), were published in 2004 (Agostini et al., 2004). The conclusions of the study were that ethanol has a higher efficiency but also more significant adverse effects, being indicated for voluminous cysts, followed by drainage for 7 days, while aethoxysklerol has fewer side effects but also a lower efficiency, being indicated for smaller cysts, followed by drainage for 4 days. Other data in the literature argue that continuous aspiration is more effective than simple drainage performed in a single session in the case of voluminous cysts, but the two methods have similar efficiency in the case of average volume cysts (Zerem et al., 2008).

Other sclerosing agents have also shown good results, similar to those of alcohol instillations. Thus, favorable effects, with rates of complete regression of approximately 66%, have been reported with the use of 50% acetic acid (Kwon et al., 2007), and other authors (Seo et al., 2000) claim that it has a faster effect and is more efficient compared to ethanol.

Studies using minocycline (Ohkawa et al., 1993) and povidone iodine (Phelan et al., 1999) demonstrated an efficacy comparable to ethanol. In a study conducted by El Harrech et al. (2009), a complete regression of symptoms was observed in 92% of cases and the disappearance of cysts in 60% of them, after a mean period of 14 months.

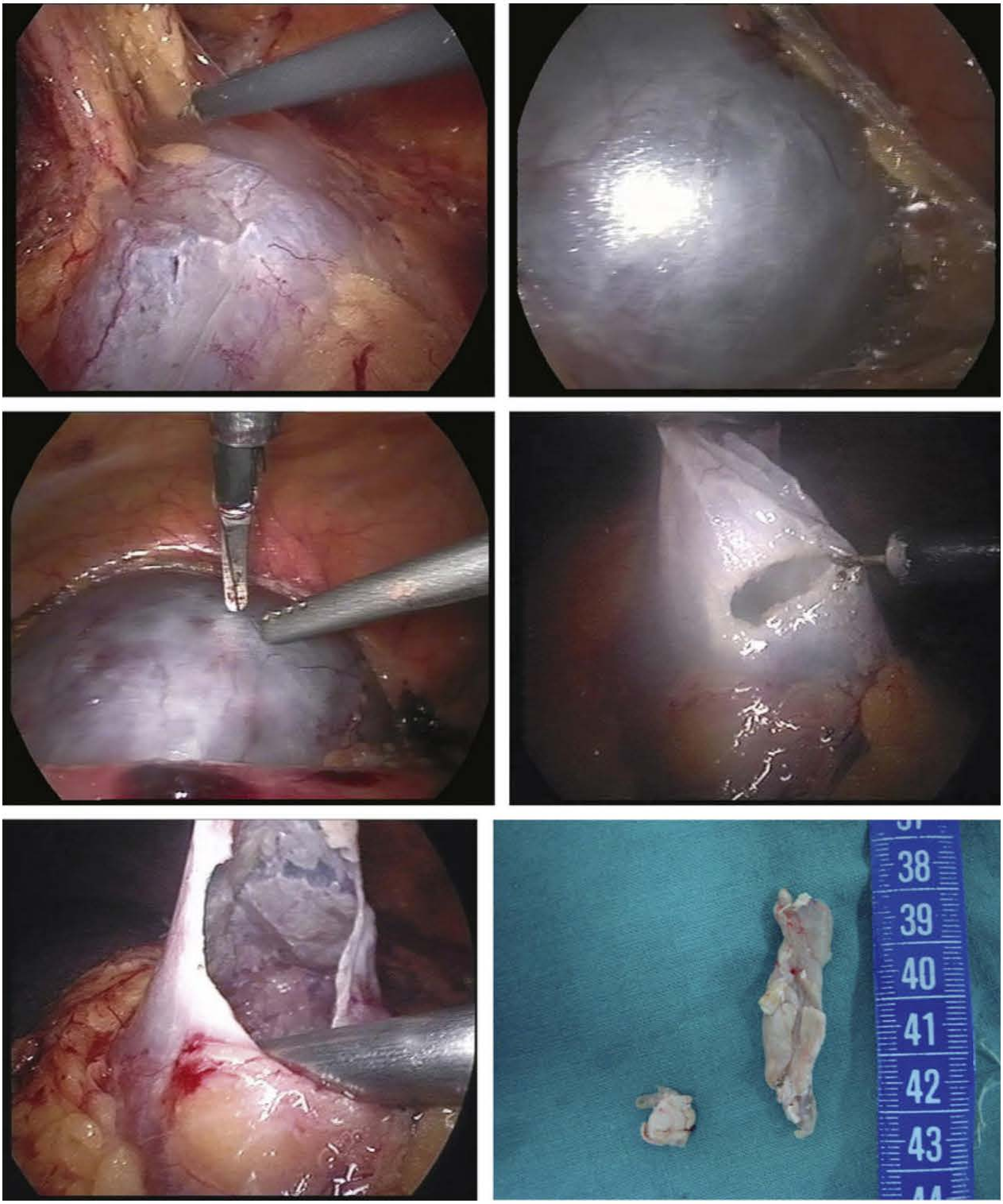
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FIGURE 9.14 **Laparoscopic decortication of a voluminous renal cyst.**

On the other hand, a study conducted on a group of 16 patients showed poor results for the use of povidone iodine, 75% of patients requiring additional therapeutic measures (Madeb et al., 2006). Tetracycline also ensured success rates of 87.5% (Kilinc et al., 2008).

The combination of ethanol and tetracycline (Liatsikos et al., 2000) proved to be effective and safe, with a success rate in terms of symptoms remission of 96%.

Another study conducted in 2005 on the efficiency of ethanolamine oleate demonstrated a mean reduction of the cystic volume of over 90% (Yamamoto et al., 2005). Performing percutaneous fulguration of the cyst's mucosa in a group of 32 patients led to a success rate of 100% in terms of symptoms remission (Busato and Bettega, 2010).

A residual cyst does not require treatment, excepting the cases in which the symptoms persist (Falci-Júnior et al., 2005).

In the case of inefficiency of the percutaneous approach of serous renal cysts, of repeated relapses, of hemorrhagic, infected cysts or of cysts with tumoral content, laparoscopic or open surgical approach is recommended.

9.7 OTHER THERAPEUTIC METHODS

Other minimally invasive therapeutic modalities include the retrograde ureteroscopic approach with intrarenal marsupialization of the cyst, marsupialization as well as resection, or laparoscopic unroofing (Morgan and Rader, 1992).

Retrograde ureteroscopic marsupialization was first described in Kavoussi et al. (1991). With the progress regarding flexible ureteroscopes, the method became easier to perform (Leone et al., 2010). A recent study using this method in a group of 16 patients showed a success rate of 93% after a follow-up period of 2 years (Li et al., 2011).

The first laparoscopic cyst resection was performed in 1992 by Winfield.

The indications for laparoscopic cystic decortication include:

- simple cysts in which aspiration followed by sclerotherapy was not efficient
- cysts located near the collecting system or which have a possible communication with the pyelocaliceal system
- parapyelic cysts
- cysts suspected of malignancy
- autosomal dominant polycystic kidney disease

Laparoscopic decortication (Fig. 9.14) of the cyst can be achieved either by transperitoneal or retroperitoneal approach. For simple cysts, the approach can be imposed by their location, the retroperitoneal one recommended for those located posteriorly, with the transperitoneal one recommended for those located anteriorly.

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CHAPTER

10

Percutaneous Approach of Renal and Perirenal Suppurations

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10.1 GENERALITIES

Renal abscess is a circumscribed suppurated collection in the renal parenchyma. Although ascending urinary tract infections with Gram-negative germs seem to be responsible for most cases of renal abscesses in adults, another modality of septic seeding can be the hematogenous one.

Fever and lumbar or abdominal pain are the most common signs and symptoms, and imaging diagnosis is achieved by ultrasonography, urography, and computed tomography (CT) (Fig. 10.1). The predisposing factors include diabetes mellitus, upper urinary tract lithiasis, renal obstruction, renal insufficiency, systemic diseases, recent surgery, and immunosuppression.

Modern diagnostic methods and interventional radiological techniques have modified the therapeutic management of renal abscesses in the last decades. For selected cases of renal abscesses, percutaneous treatment combined with antibiotic therapy represents the standard therapy to date, with a decrease in morbidity, mortality, hospitalization period, and costs.

Percutaneous drainage represents an efficient and safe alternative to open surgical drainage. When it is not curative, percutaneous treatment may allow the stabilization of the patient until the curative intervention.

10.2 INDICATIONS

Percutaneous approach of renal abscesses, which implies the percutaneous aspiration and/or drainage of these lesions (Sadi et al., 1988), is an efficient therapeutic alternative, situated at the border between medical treatment and surgical drainage (Deyoe et al., 1990). This minimally invasive approach may allow either the conversion of an emergency surgical intervention into a scheduled, elective intervention or, together with parenteral antibiotic treatment, represent a definitive treatment method.

Percutaneous treatment is recommended especially in the case of medium renal abscesses, with dimensions ranging between 3 cm and 5 cm (Siegel et al., 1996). For abscesses smaller than 3 cm, in immunocompetent patients, conservative treatment is preferred, with long-term antibiotherapy for up to 6 weeks.

There are cases, such as immunosuppressed patients or in the case of the lack of response to medical treatment, in which percutaneous treatment can be performed, even at these dimensions.

Large renal abscesses have the indication for open surgical drainage. However, abscesses with a diameter larger than 5 cm may also be treated percutaneously, but usually require several drainage procedures to obtain full resolution.

However, in many cases, complete resolution requires open surgery at the end (Siegel et al., 1996). Percutaneous drainage may improve the patient's clinical status, so that an eventual subsequent elective nephrectomy can be performed in safer conditions (Lenk et al., 2005).

Perirenal suppurations may benefit from percutaneous drainage if they are relatively circumscribed and of medium size, especially in patients with a high risk in the case of open surgery.

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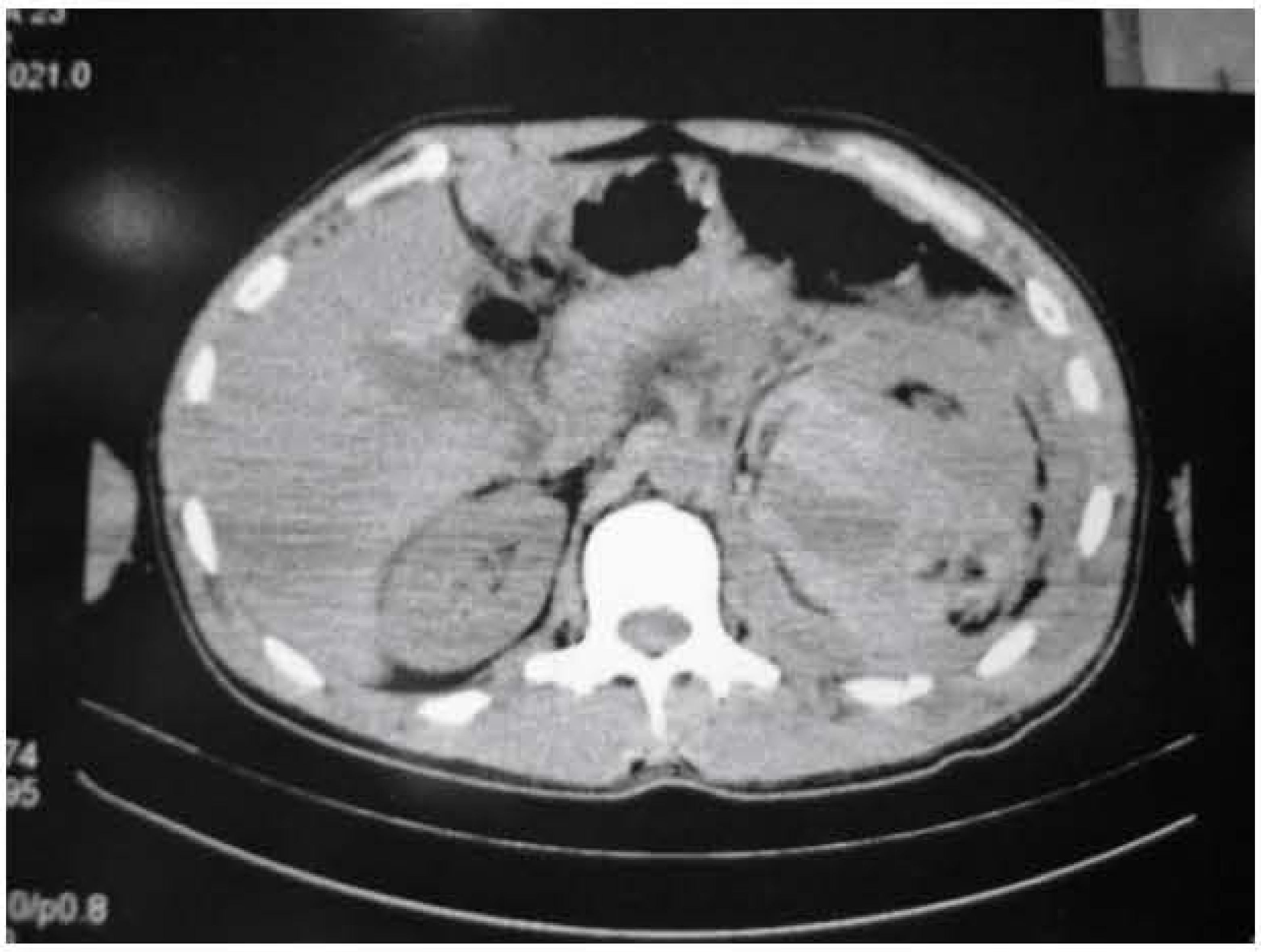

FIGURE 10.1 Left renal abscess (CT aspect).

10.3 TECHNIQUES

10.3.1 Patient Positioning

The percutaneous approach of renal abscesses is performed with the patient in dorsal or lateral decubitus.

10.3.2 Anesthesia

Regarding anesthesia, it must be taken into account that patients with renal abscesses often present sepsis. For this reason the procedure is usually carried out under local anesthesia, associated or not with intravenous sedation.

10.3.3 Control of the Intervention

The identification and characterization of the abscess will be achieved by ultrasonography or by magnetic resonance imaging (Wildberger and Günther, 2007) and CT.

Ultrasonography is also useful for monitoring the entire process of puncturing and evacuating the purulent content. CT allows for an excellent visualization of the anatomical details, an accurate and easy placement of the puncture needle, as well as the placement of the guidewire inside the cavity. However, ultrasonography is a very useful, cheap, and extremely accessible method for the urologist, allowing to puncture and place the guidewire. Fluoroscopy can also be used to place the metallic guidewire and to advance the drainage catheter through it, inside the collection (Deyoe et al., 1990).

10.3.4 Cavity Puncture

Percutaneous treatment is usually performed through a posterior approach, below the XII-th rib, because the anterior approach could intersect the peritoneal cavity, a more lateral approach could injure the colon, while a higher approach could damage the pleura (Cronan et al., 1984). Any of the previously mentioned complications almost always implies the septic seeding of the cavities, with extremely serious consequences.

The percutaneous puncture is made using an 18–22G needle with a mandrel (Seldinger technique) or with a trocar.

10.3.5 Evacuation of the Purulent Content

After the puncture, the mandrel is removed and the content is aspirated. If the macroscopic aspect confirms the presence of pus, placement of the percutaneous catheter is taken into consideration (Cronan et al., 1984).

After samples of the purulent content are taken for bacteriological examination, the opacification of the cavity using contrast medium allows an estimation of the collection's volume and eventual leakages.

Pus evacuation from the abscess may be facilitated by lavage with saline solution, frequently associated with antibiotics *in situ* (Bacha et al., 2001).

10.3.6 Abscess Drainage

Percutaneous drainage using a multiple perforated catheter is the percutaneous therapeutic alternative most frequently used and described in the literature.

It involves the insertion of a reinforced metallic guidewire that is advanced inside the abscess, followed by progressive dilation using fascial dilators. After the dilation of the tract, the catheter is inserted. An option is represented by the insertion of the catheter using a trocar. However, the latter method is being used less and less often.

The size of the multiple perforated drainage catheter will be chosen according to the characteristics of the purulent content. Thus, its caliber will be increasingly larger as the pus is more consistent, usually an 8–12 F catheter being used.

A therapeutic alternative is represented by simple percutaneous aspiration of the abscess, without placing a drainage tube (Shu et al., 2004). Some authors recommend that the percutaneous drainage should be taken into consideration only when the abscess is very large or if complete aspiration has failed (Chakroun et al., 1992).

10.4 COMPLEMENTARY MEASURES FOR PERCUTANEOUS DRAINAGE

Percutaneous treatment should be supported by multiple antibiotic therapy and hydroelectrolytic rebalancing measures. Antibiotic treatment will initially be chosen empirically, with a broad spectrum, and subsequently it will be adjusted according to the result of the bacterial culture with antibiogram.

If the renal abscess is associated with renal lithiasis with obstruction or infection, the cavity's approach must be accompanied by the placement of a nephrostomy or at least a JJ stent to drain the collecting system (Lenk et al., 2005).

10.5 EXTRACTING THE DRAINAGE TUBE

The drainage catheter is maintained for a period ranging from 5–11 days (Cronan et al., 1984) to 2–4 weeks (Deyoe et al., 1990). The catheter is removed when the signs and symptoms have remitted, the laboratory tests (especially the blood count) have normalized, drainage has ceased for at least 48 h, and the injection of the contrast medium into the cavity no longer reveals a residual cavity (Cronan et al., 1984).

10.6 COMPLICATIONS

Complications may occur in 8–10% of cases, and are represented by bleeding, fistulas, septic shock, pneumothorax, pleural empyema, etc. (Bacha et al., 2001).

Failure of the percutaneous treatment should also be considered a complication that usually requires open surgical exploration or even secondary nephrectomy. A minor, yet frequent complication is transient fever after placing or manipulating the catheter, most probably due to bacteremia that accompanies the percutaneous maneuvers (Deyoe et al., 1990). Septic shock may occur in a smaller number of cases, with a potentially lethal evolution.

Injury of the pleural cavity during percutaneous treatment may lead to severe complications such as pneumothorax or empyema that may require subsequent thoracic surgical interventions (Lenk et al., 2005). Other possible complications are represented by intestinal injuries or the seeding of the peritoneal cavity followed by secondary peritonitis (Lenk et al., 2005).

10.7 RESULTS

The success rate for percutaneous treatment of renal abscesses varies in the literature between 82% and 97% (Lenk et al., 2005).

The most important determinants for the success of percutaneous drainage are represented by the size of the abscess, the fluid's consistency, and the presence of eventual septa. Large abscesses may require repeated percutaneous drainage procedures or, at the end, the treatment could be completed by open surgery (Lenk et al., 2005).

In a series of patients with renal abscesses of medium sizes (3–5 cm) treated by percutaneous drainage, Siegel reported a success rate of 92% and an overall success rate for percutaneous monotherapy (regardless of the dimensions) of 79%. On the other hand, abscesses larger than 5 cm required more than one drainage procedure in 33% of cases or an open surgical intervention in 37% of cases (Siegel et al., 1996).

Bacha et al. (2001), for a group of 25 patients with renal abscesses treated percutaneously, reported a success rate of 80%, failure being related to the large volume of the collection, the increased consistency of the purulent content, the existence of septa, or upper polar localization.

The percentage of patients in whom percutaneous treatment was used only as a step prior to open surgery may reach 27–37% (Deyoe et al., 1990).

The results of percutaneous treatment in properly selected cases seem to be stable in time, no recurrences being recorded over a follow-up period of 4–28 months (Cronan et al., 1984).

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CHAPTER

11

Percutaneous Approach of Upper Urinary Tract Iatrogenic Lesions

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The intensive development of new therapeutic methods and techniques, associated with the appearance of high-quality and reliable instruments, has not been able to completely prevent upper urinary tract injuries due to the surgical act. Minimally invasive percutaneous approach remains a first-line treatment solution for these injuries, regardless of their etiopathogeny: after open surgical procedures, endoscopic (retrograde or percutaneous) interventions, or those secondary to the placement of urinary stents.

Iatrogenic lesions of the upper urinary tract may occur following open surgical interventions on the urinary tract, as well as after gynecological interventions, colon interventions (Fig. 11.1), interventions on great vessels, etc.

Iatrogenic ureteral trauma represents the most common cause of ureteral injuries. Over 75% of them are due to surgical interventions, whereas 18% and, respectively, 7% of cases occur after contusions and penetrating trauma (Teber et al., 2005; Dobrowolski et al., 2002).

The most frequently encountered mechanisms after open surgery are represented by:

- improper application of a clamp
- ligation
- sectioning (partial or total)
- angulation of the ureter with secondary obstruction (Fig. 11.2)
- ischemia due to ureteral stripping or electrocauterization
- resection of a ureteral segment
- a combination of the previous points

Gynecological surgery (especially classic hysterectomy) is responsible for three-quarters of iatrogenic ureteral lesions (Teber et al., 2005; Drake and Noble, 1998).

Most cases affected during these interventions occur as a consequence of ureteral ligation with threads placed to control bleeding from the uterine vessels. The ureter may also be injured due to sectioning (Rajasekar and Hall, 1997).

In the case of ureteral ligation, placing a nephrostomy tube may be sufficient, providing the time needed for the absorption of the suture threads (Harshman et al., 1982). A success rate of 80% has been reported in the literature for the use only of percutaneous nephrostomy (Lask et al., 1995). However, high urinary diversion associated with the dilation of the affected ureteral segment or incision of the resulting stenotic area, followed by the placement of a ureteral stent, provides better results. Another method, useful especially in the case of transfixation threads, is the endoscopic approach with suture thread sectioning (Fig. 11.3).

Also, the increasingly widespread use of endoscopic and laparoscopic minimally invasive techniques has led to an increase in the number of traumatic ureteral lesions (Fig. 11.4) (Harkki-Sirén et al., 1998; Selzman and Spirnak, 1996; Drake and Noble, 1998).

Retrograde ureteroscopy is, currently, a first-choice method in the treatment of ureteral lithiasis. Compared to previous years, the technique has become safer, complications occurring less frequently, due to the perfecting of instruments and an increase in the operators' experience. A 7% average rate of complications is estimated (McAninch and Santucci, 2002).

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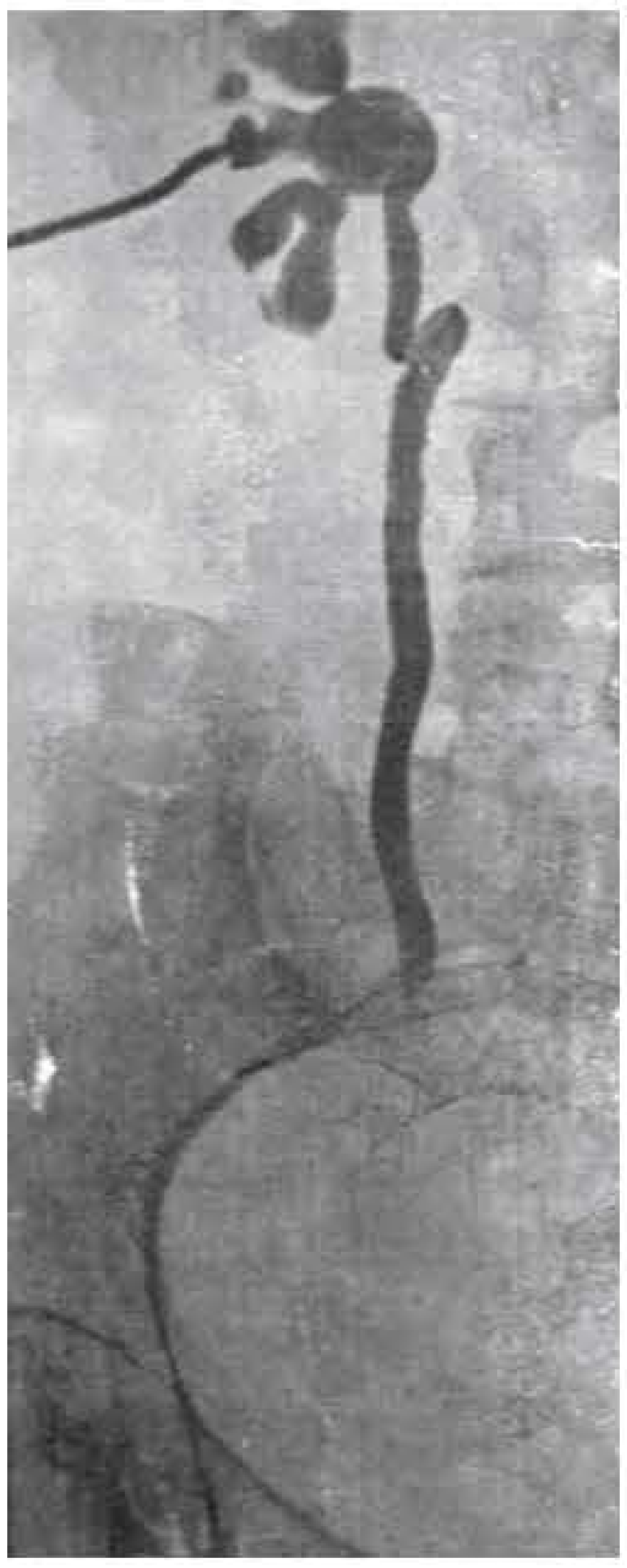

FIGURE 11.1 **Ligation of the pelvic ureter after intervention on the colon, for which percutaneous nephrostomy was performed.**

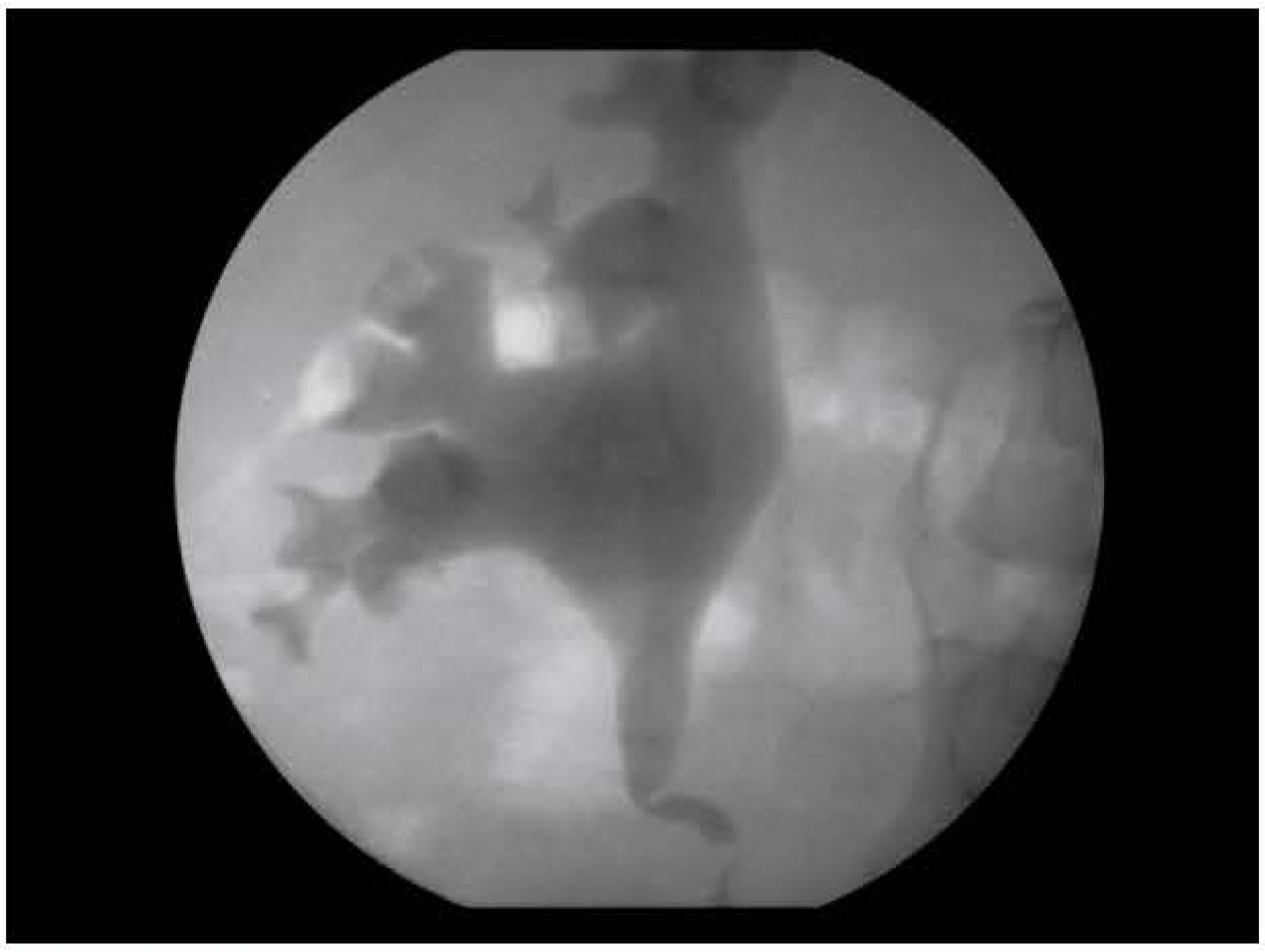

FIGURE 11.2 **Iatrogenic ureteral angulation with dilation of the suprajacent urinary tract.**

Ureteral traumas that are not accurately diagnosed in the first instance or that occur in an unstable patient must benefit from drainage of the renal unit through percutaneous nephrostomy, this method being superior to the insertion of a JJ stent because of its safety and ease of applying (Armenakas, 1999).

Urinary leakage can occur due to ureteral wall injuries (Fig. 11.5) and leads to retroperitoneal urinoma. The incidence of urinary leakage in different studies ranged from 0.6% to 1% but, because intraoperative retrograde pyelography is not routinely recommended, it is possible that the true incidence of this complication is underestimated.

The degree of leakage is directly related to the dimensions of the parietal lesion and the moment of perforation. The presence of associated urinary infection can cause retroperitoneal abscesses. Some studies have shown that urinary leakage leads to periureteral fibrosis. In the case of important leakage, if ureteral stenting cannot be performed, percutaneous nephrostomy may ensure adequate drainage and healing without sequelae.

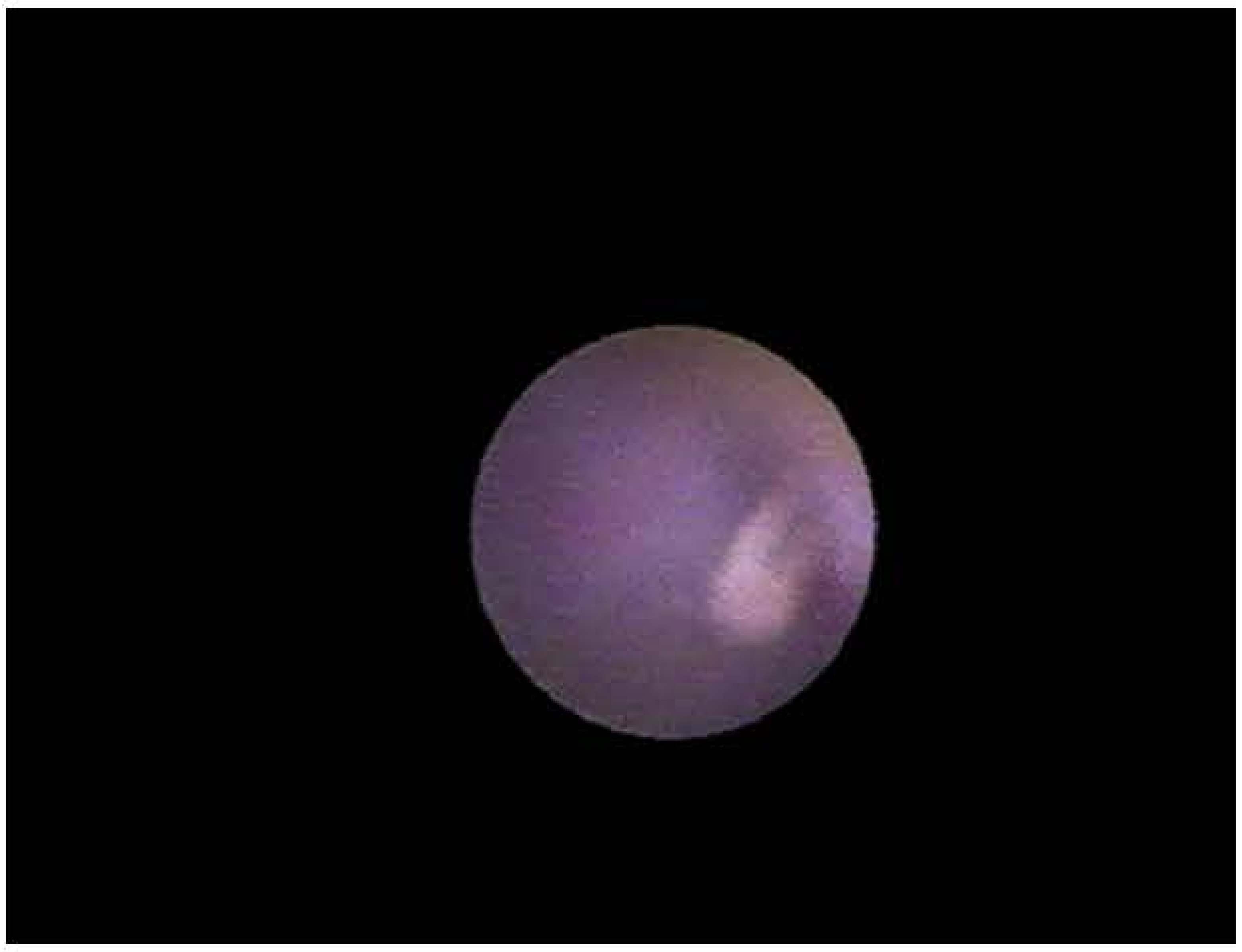

FIGURE 11.3 **Ureteral lumen occluded by suture thread (ureteroscopic appearance).**

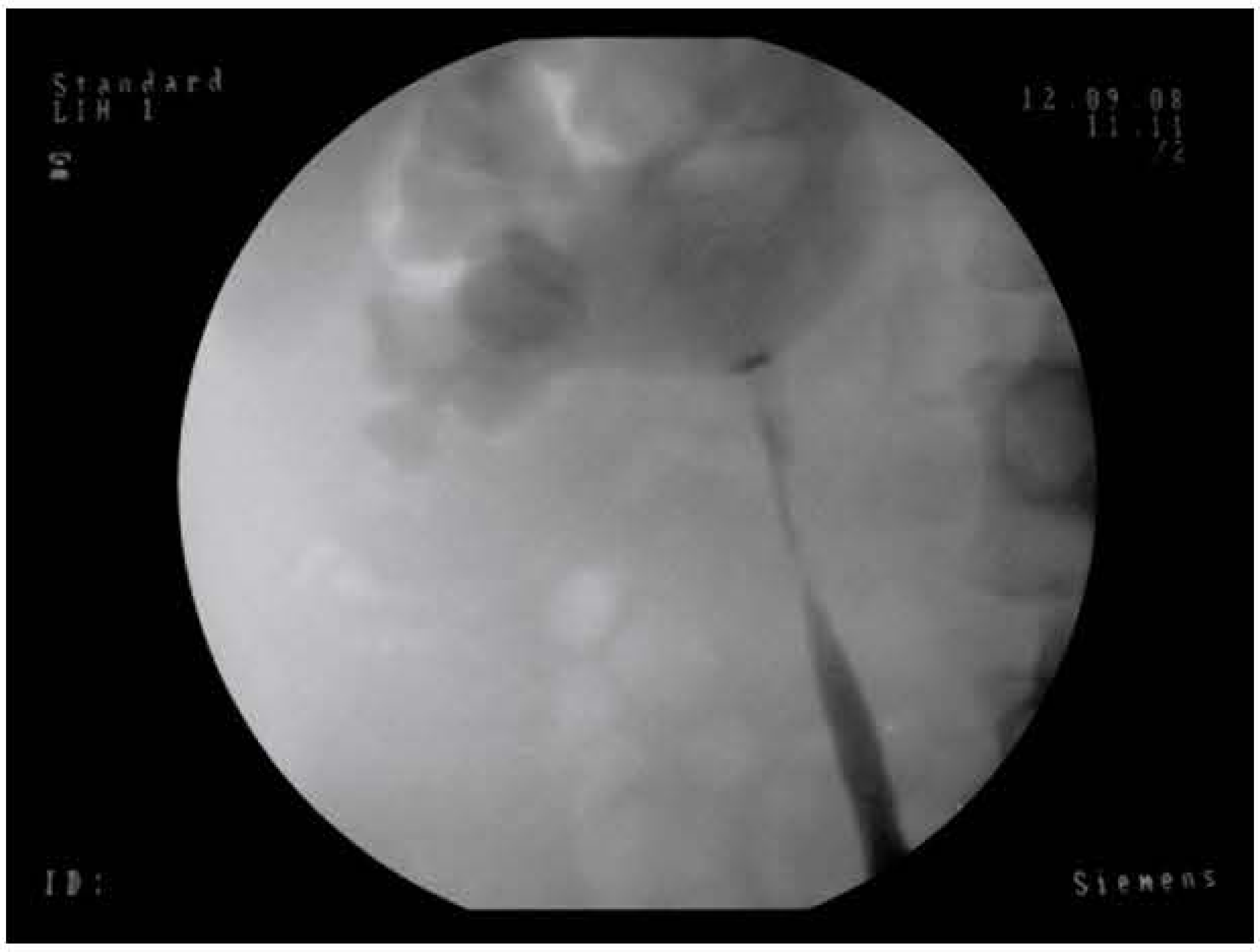

FIGURE 11.4 **Postretrograde ureteroscopy ureteral stenosis.**

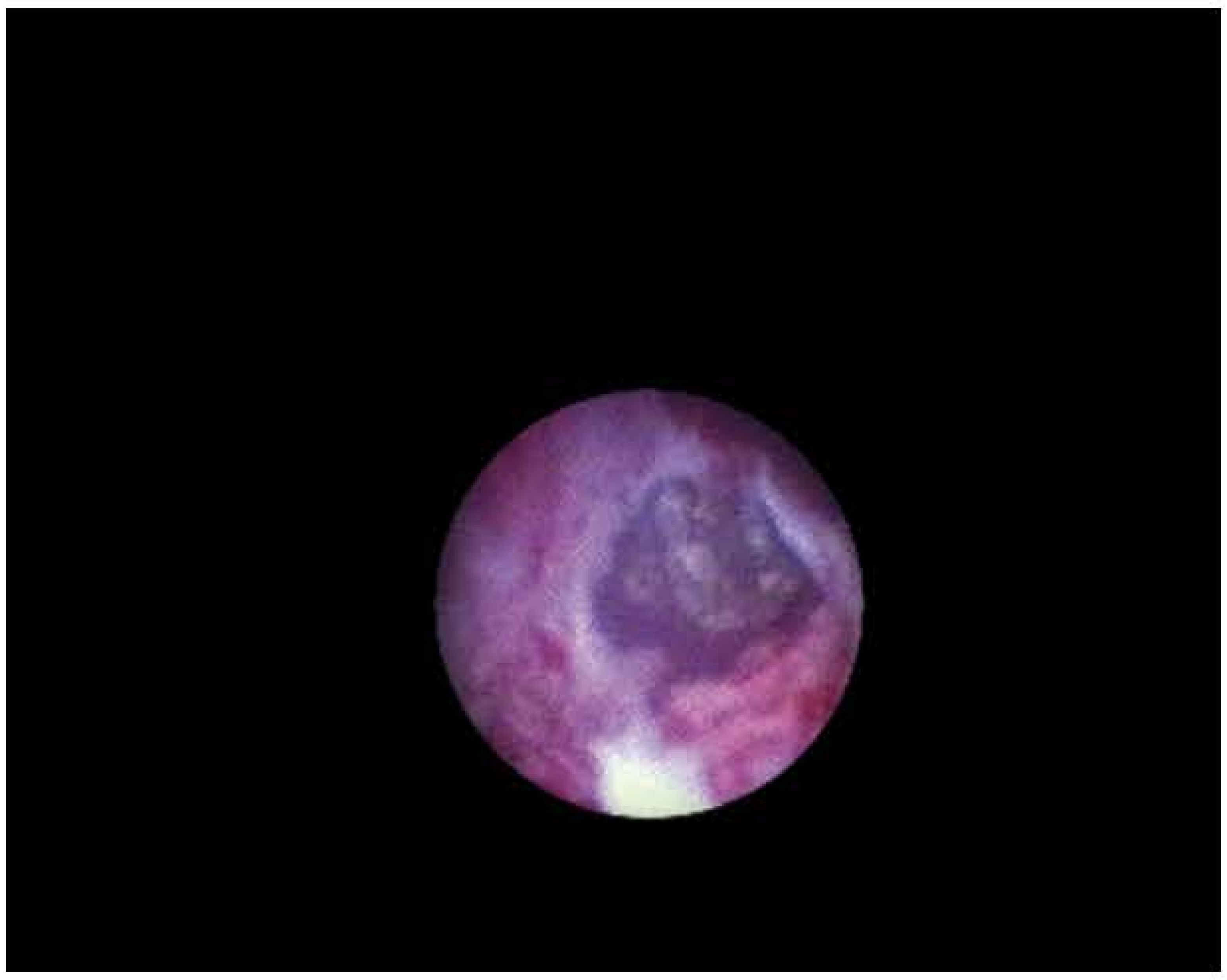

FIGURE 11.5 **Iatrogenic stone migration due to perforation of the ureteral wall.**

Damage of the narrowed intramural ureter often allows continuing the ureteroscopy by identifying the lumen and ascending a ureteral catheter under direct visualization, through which the endoscope is then advanced. In the case of failure of this maneuver, performing percutaneous nephrostomy is indicated.

Partial ureteral avulsion (Fig. 11.6) is a rarer complication that causes less severe sequelae. If a safety guidewire was not ascended during the procedure and the lesion could not be passed with a guidewire, percutaneous nephrostomy and antegrade ureteral endoprosthesis are indicated (Stoller and Wolf, 1996).

A recent study (Koukouras et al., 2010) analyzed a group of 24 patients who suffered iatrogenic ureteral injuries (Fig. 11.7). These occurred after hysterectomy, ureteroscopy, colorectal surgery, colorectal pyeloplasty, percutaneous nephrolithotomy, correction of vesico-vaginal fistulas, and renal cyst ablation. Minimally percutaneous approach of the affected kidney was performed in all these cases.

The first step of the intervention was to perform a standard nephrostomy tract. This was followed by antegrade catheterization with a ureteral catheter on a reinforced metallic guidewire. The injection of contrast medium allowed opacifying the pyelocaliceal system and accurately locating the affected ureteral area. In cases with lesions of the ureteral wall, a JJ ureteral stent was antegradely installed. To maintain an efficient drainage of the kidney, a mono J catheter was also placed.

In patients who presented ureteral stenoses, dilation with a balloon catheter was performed (Fig. 11.8).

Another efficient therapeutic alternative for treating iatrogenic ureteral stenoses is the bipolar approach (Yates et al., 2010).

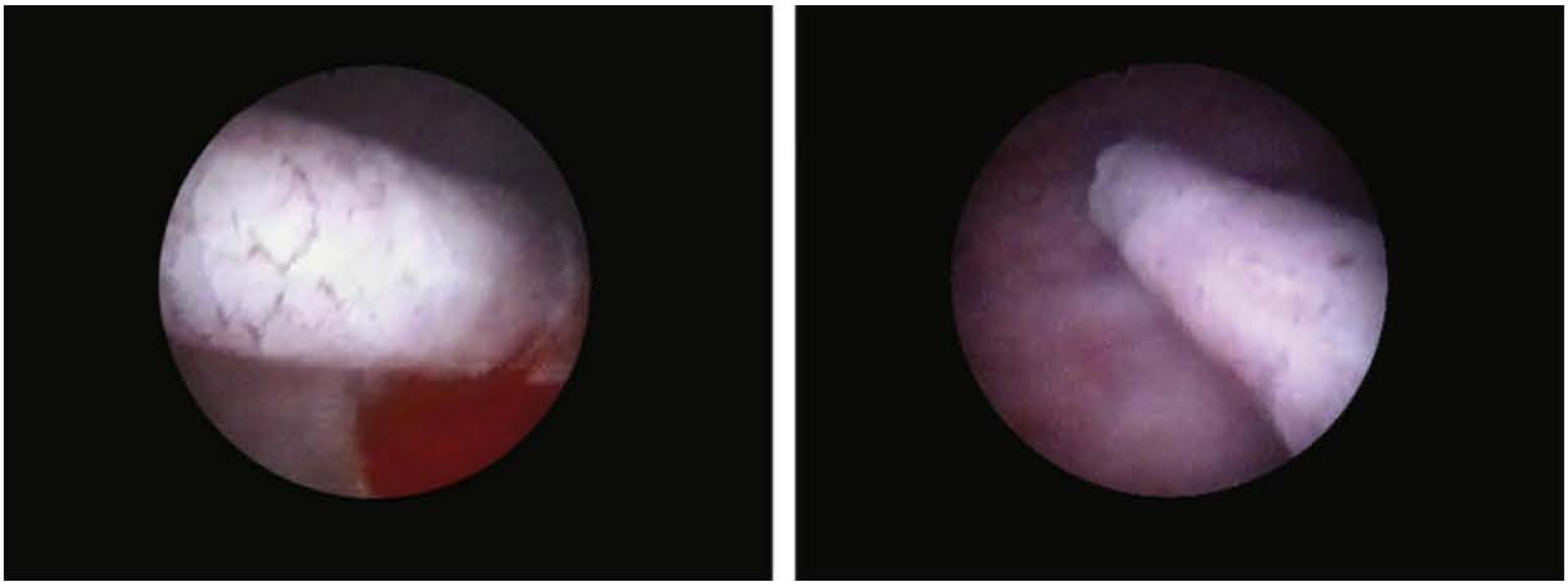

FIGURE 11.6 **Iatrogenic ureteral avulsion during ureteroscopy.**

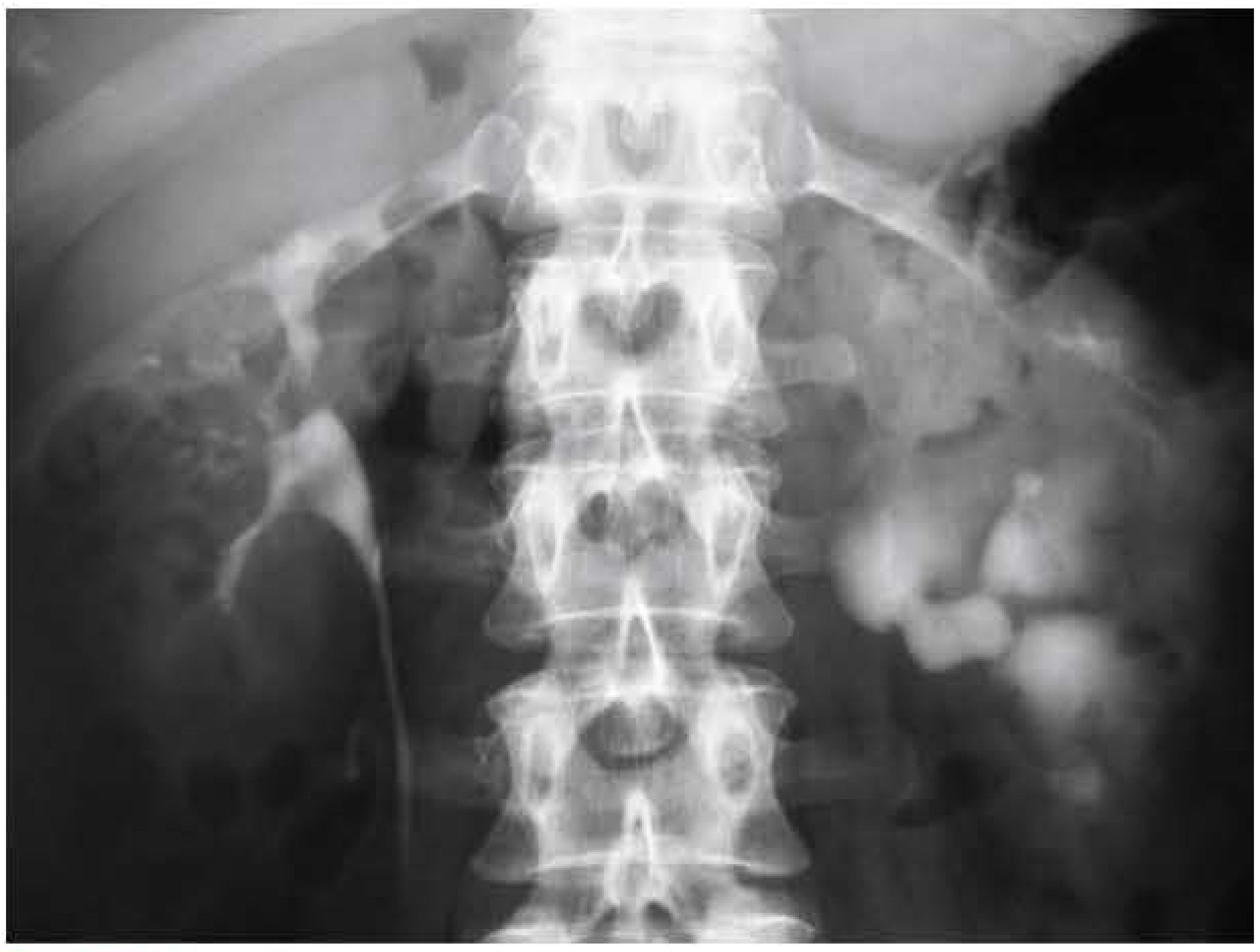

FIGURE 11.7 **Left hydronephrosis secondary to an iatrogenic ureteral stenosis.**

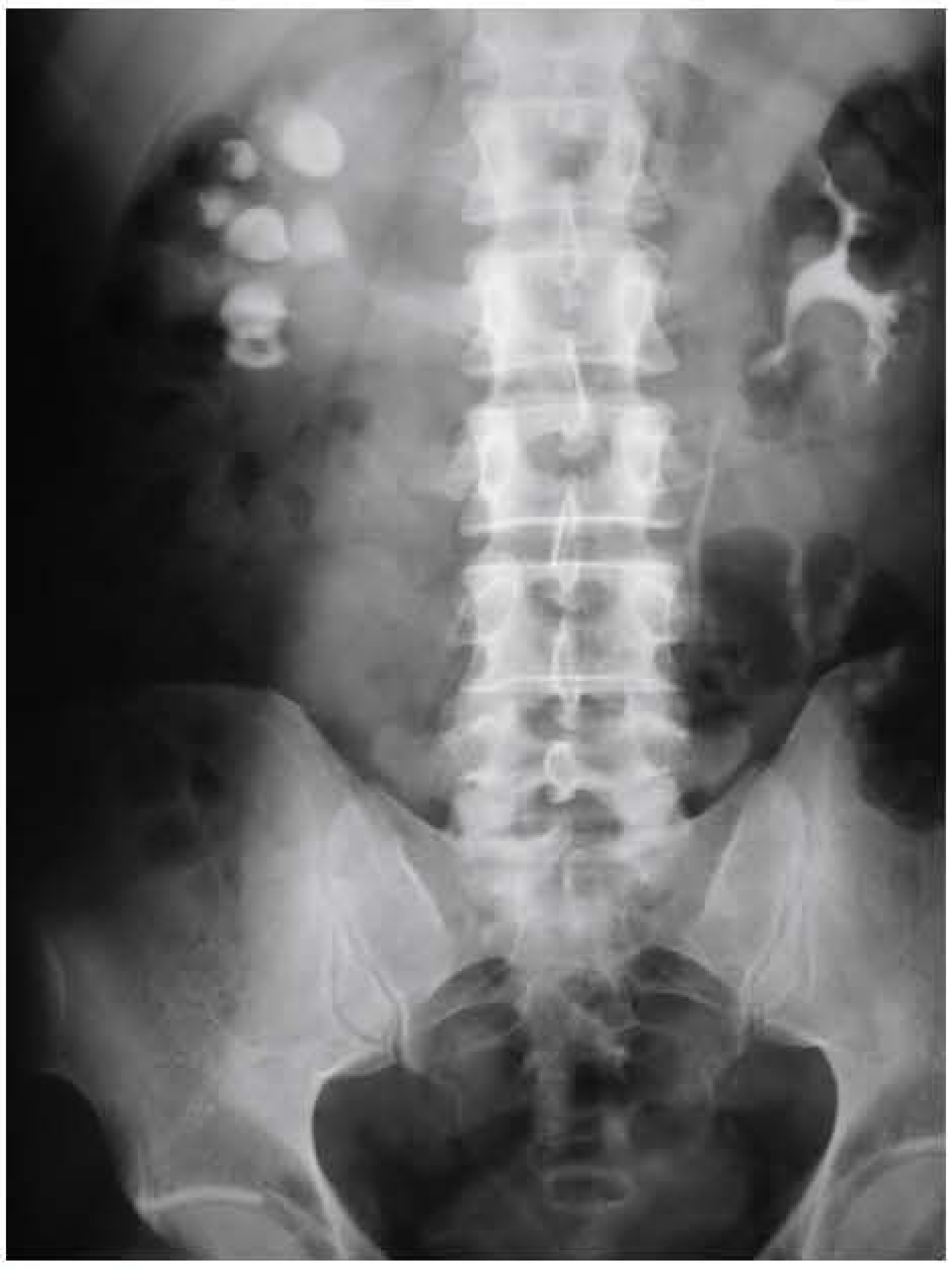

FIGURE 11.8 **Right ureteral stenosis.**

Other situations that frequently require performing percutaneous nephrostomy (if placement of a ureteral stent fails) are represented by uretero-cutaneous, uretero-vaginal, or uretero-enteral fistulas, this maneuver being followed, in time, by the healing and closing of the fistula (Lang et al., 1979; Dowling et al., 1986).

Another condition that benefits from the minimally invasive percutaneous approach is represented by secondary lesions occurring after radiotherapy, developing sometimes after a long period of time, as stenotic areas, difficult to treat due to the quality of the tissue. In this case, placing a double J catheter or a percutaneous nephrostomy is the only solution for urinary drainage before nephrectomy.

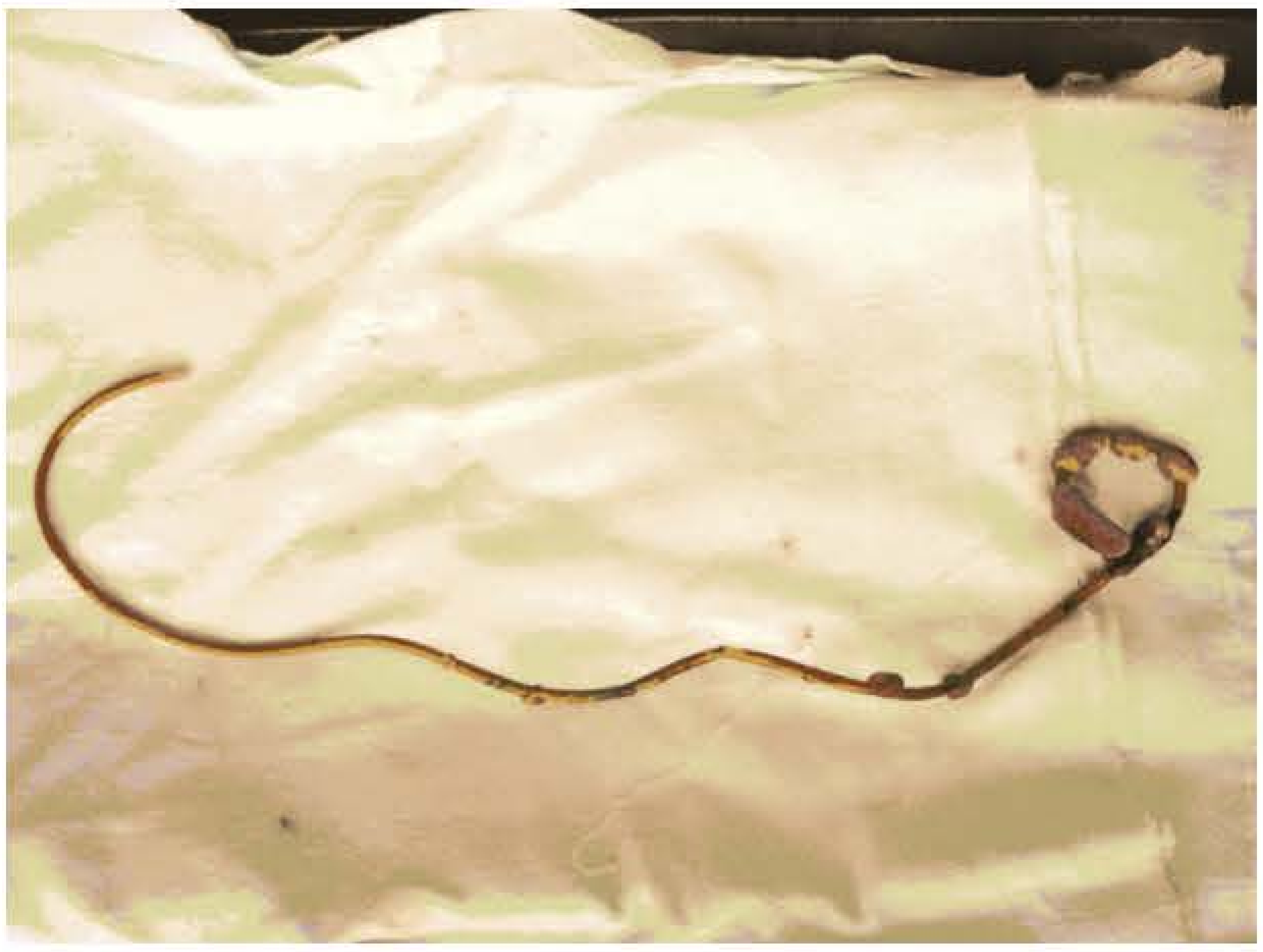

FIGURE 11.9 **Calcifications of the upper part of a JJ catheter.**

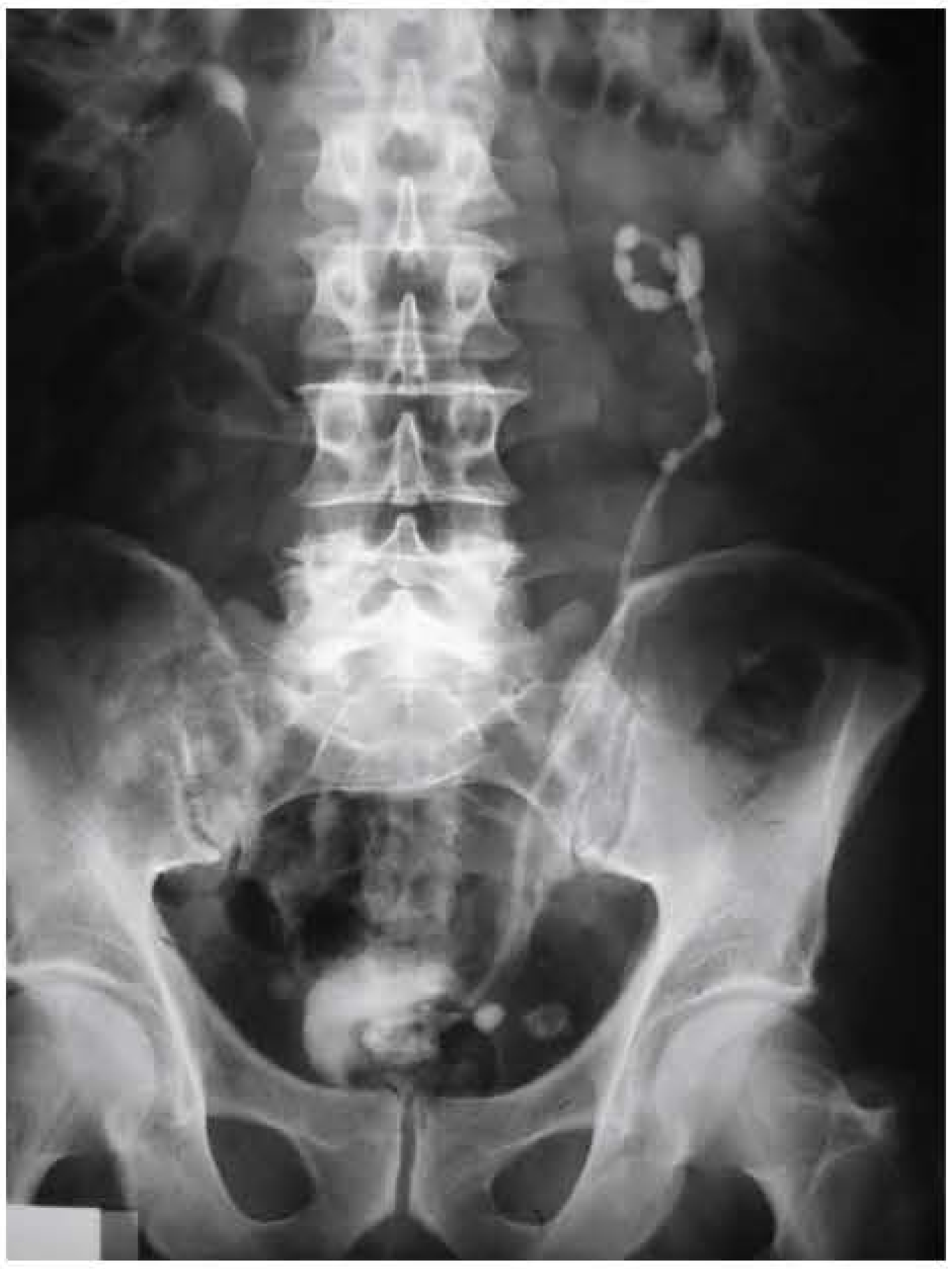

FIGURE 11.10 **Calcified JJ stent (simple reno-vesical radiography).**

The increasingly frequent use of ureteral stents is followed by an increase in the number of complications related to these. The percutaneous approach is a solution in cases in which access to the pyelocaliceal system cannot be achieved through retrograde techniques.

The obstruction of a recently implanted ureteral stent can be determined by hematuria secondary to the operative maneuvers or due to pyuria or an increased viscosity of urine associated with tissue debris, when an infected urinary tract is approached (Mitty, 2000). This last circumstance should be treated very carefully, percutaneous nephrostomy being preferred over the placement of a ureteral stent (Zagoria, 1997; Franczyk and Gray, 1989).

Their lithiasic encrustation is another serious complication (Fig. 11.9), several methods being used to extract the stents.

Thus, Lam and Gupta (2002) reported a number of four percutaneous nephrolithotomies (using the semirigid or flexible nephroscope), while in five other cases the authors used antegrade ureteroscopy (with or without laser lithotripsy) to fragment the proximal loop of the JJ stent. In another study conducted by Bultitude et al. (2003) in a group of 41 patients who had encrusted stents, the percutaneous approach was successfully used in 5 cases (Fig. 11.10).

The spontaneous fragmentation of a ureteral stent (Fig. 11.11) represents a relatively rare complication, with a prevalence of 0.3–10% (Ringel et al., 2000; Kumar et al., 1999). Symptoms may consist of sepsis, bleeding, or colicky pain. In this context we can mention a case in which the minimally invasive percutaneous approach led to the extraction of the stent (Fig. 11.12) and of the existing lithiasic pieces (using percutaneous nephrolithotomy) (Kumar et al., 1999).

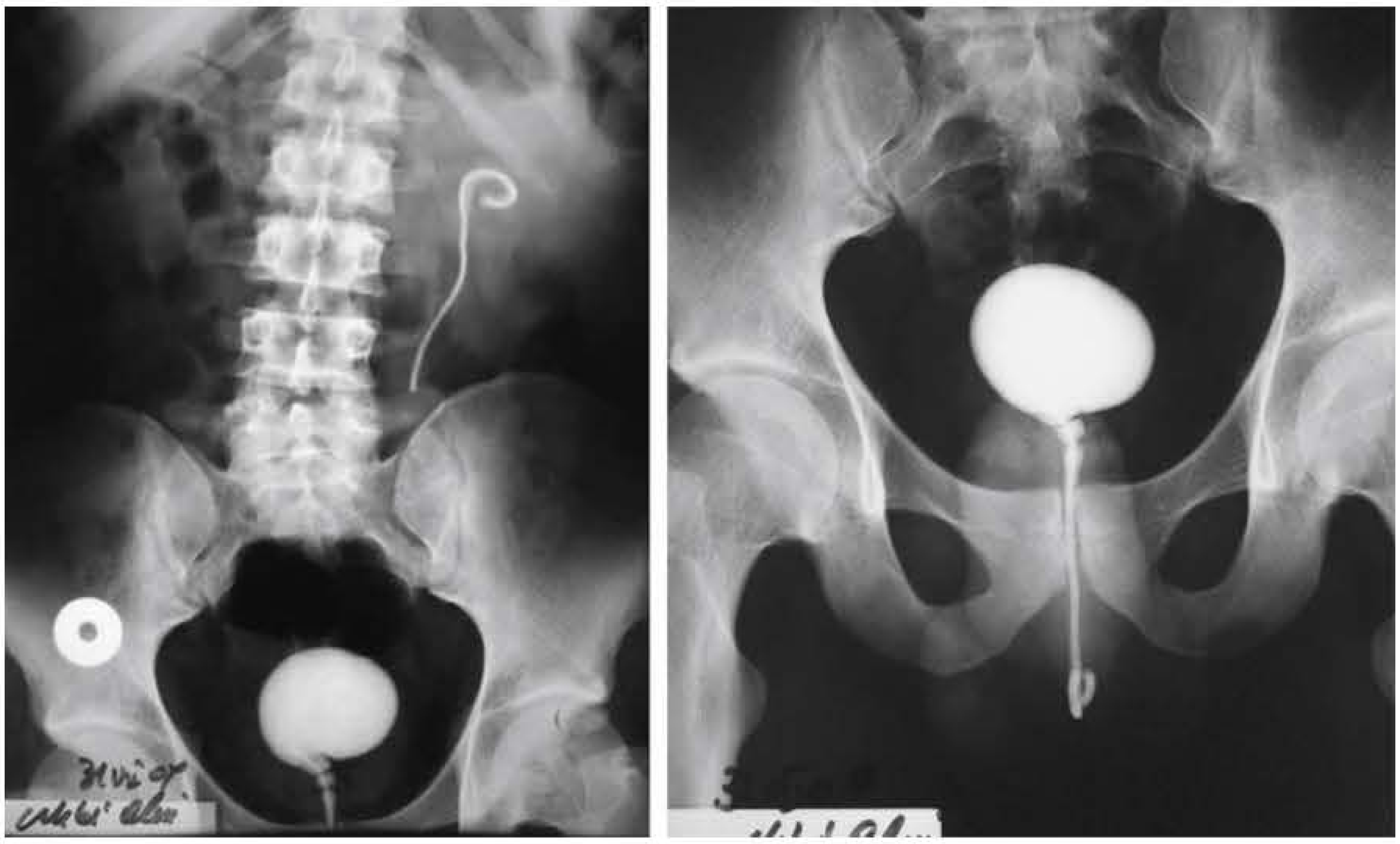

FIGURE 11.11 **Fragmentation of a JJ stent (simple reno-vesical radiography).**

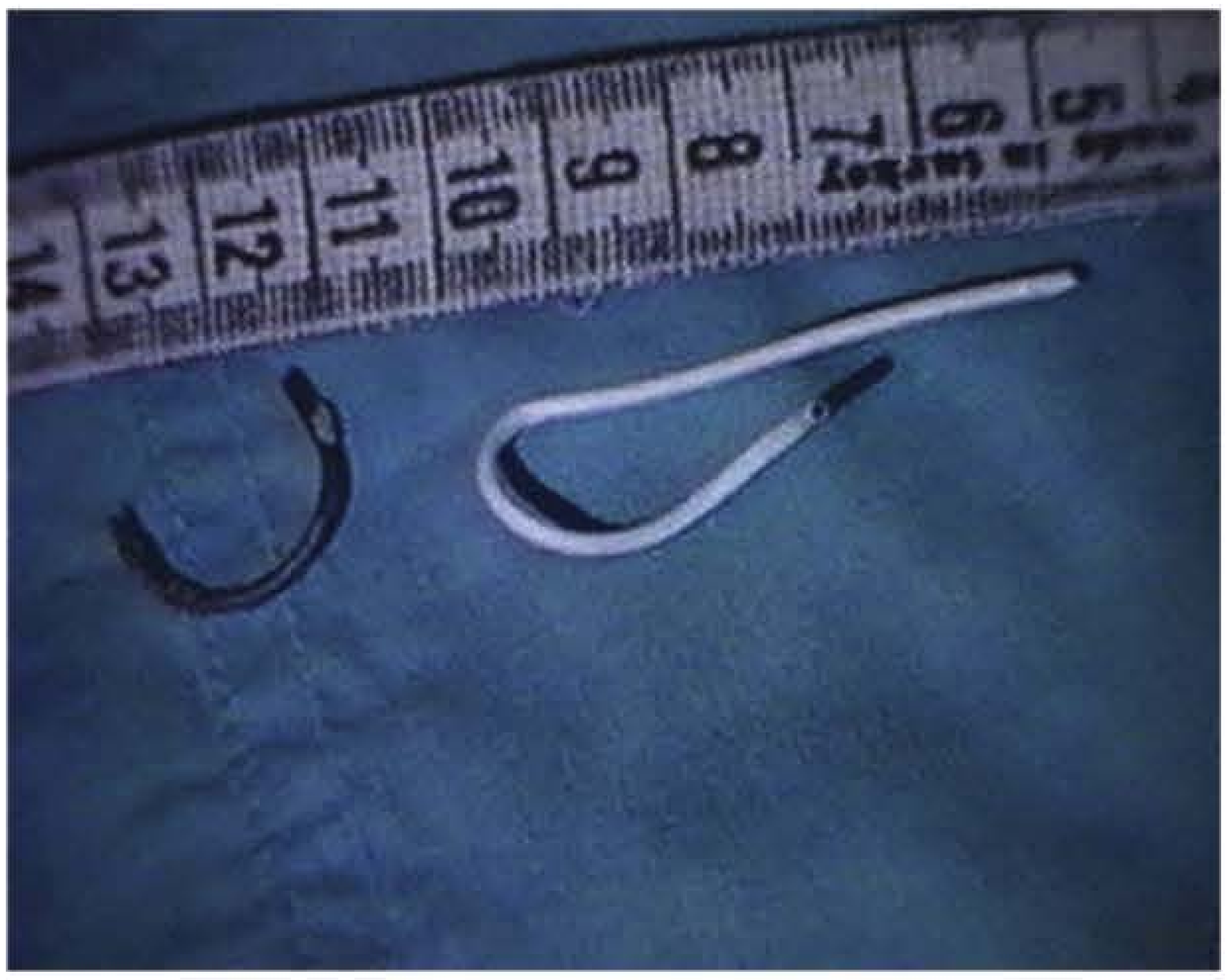

FIGURE 11.12 **Two fragments of a JJ stent.**

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Percutaneous Surgery of the Upper Urinary Tract

HANDBOOK OF ENDOUROLOGY

Edited by **Petrişor Aurelian Geavlete**

Handbook of Endourology includes comprehensive descriptions and analyses of all available endoscopic methods. It was drafted by a team of urologists specifically trained in this field, based on approximately 100,000 endoscopic procedures performed over the past 25 years.

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